PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-263785
(43)Date of publication of application : 26.09.2000

(51)Int.Cl. B41J 2/045
B41J 2/055
B41J 2/16
H01L 41/09
H01L 41/22

(21)Application number : 11-073305
(22)Date of filing : 18.03.1999

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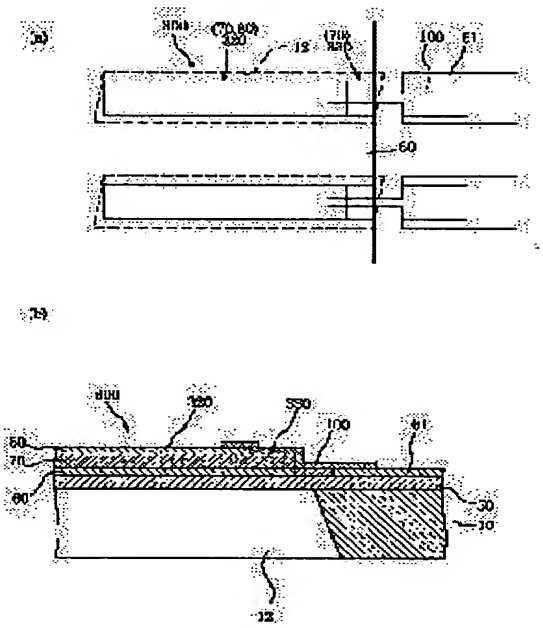
(54) ACTUATOR APPARATUS AND ITS MANUFACTURE AND INK JET TYPE RECORDING HEAD AND INK JET TYPE RECORDING APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent dielectric breakdown of a piezoelectric body layer.
SOLUTION: An end part of an upper electrode 80 is placed inside more than an end part of a lower electrode 60 to be an end part of a piezoelectric body active part 320 which is a substantial driving part of a piezoelectric element 300. A piezoelectric body layer 70 is set on the lower electrode 60 projecting outside from the end part of the upper electrode 80, thereby constituting a piezoelectric body non-active part 330 which is substantially not driven. The piezoelectric body layer 70 is also set outside the end part of the lower electrode 60 to prevent dielectric breakdown of the piezoelectric body layer 70 in the vicinity of the end part of the lower electrode 60.



LEGAL STATUS

[Date of request for examination] 14.02.2002
[Date of sending the examiner's decision of rejection] 15.10.2003
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] In the actuator equipment possessing the piezoelectric device which consists of an electrode after being prepared on the piezo electric crystal layer prepared on the bottom electrode of a substrate established in the field through the insulating layer on the other hand, and the bottom electrode of this, and this piezo electric crystal layer The edge of said top electrode is the edge of the piezo electric crystal active section which is located inside the edge of said bottom electrode and turns into a substantial actuator of said piezoelectric device. Actuator equipment characterized by preparing said piezo electric crystal layer also in the outside of the edge of said bottom electrode while constituting the piezo electric crystal non-activity section which said piezo electric crystal layer is prepared on said bottom electrode which projected outside the edge of said top electrode, and is not driven substantially.
[Claim 2] Actuator equipment with which the edge of said piezo electric crystal active section is characterized by being located inside [circumferential corkscrew twist] said pressure generating interior of a room while being prepared in the field corresponding to the pressure generating room where said piezoelectric device was formed in said substrate in claim 1.
[Claim 3] Actuator equipment characterized by installing said piezo electric crystal layer to the same location as the edge of said bottom electrode, or its outside in claim 1 or 2.
[Claim 4] Actuator equipment characterized by preparing the bottom electrode for wiring by which it sets they to be [any of claims 1-3], and is prepared outside discontinuously [said bottom electrode] at the pan of the piezo electric crystal layer prepared in the outside of the edge of said bottom electrode, and an end is connected to external wiring for said every piezoelectric device.
[Claim 5] Actuator equipment characterized by setting they being [any of claims 1-4], and for said bottom electrode covering the piezoelectric device which plurality adjoins, and being prepared continuously.
[Claim 6] Actuator equipment characterized by setting they being [any of claims 1-4], and carrying out patterning of said bottom electrode for every piezoelectric device.
[Claim 7] The ink jet type recording head characterized by joining the nozzle formation substrate which said substrate of which actuator equipment of claims 1-6 is a passage formation substrate which forms the pressure generating room which is open for free passage to a nozzle orifice, and has said nozzle orifice in the another side side side of this passage formation substrate.
[Claim 8] The ink jet type recording head characterized by forming said pressure generating room in a silicon single crystal substrate of anisotropic etching, and forming each class of said piezoelectric device by the thin film and the lithography method in claim 7.
[Claim 9] The ink jet type recording device characterized by providing claim 7 or the ink jet type recording head of 8.
[Claim 10] In the manufacture approach of the actuator equipment which forms on a substrate the piezoelectric device which carries out the laminating of a bottom electrode layer, a piezo electric crystal layer, and the top electrode layer one by one through an insulating layer, carries out patterning of each class, and consists of said bottom electrode layer, said piezo electric crystal layer, and said top electrode layer The 1st process which forms the bottom electrode layer clearance section which carried out patterning and removed said bottom electrode layer while

forming said bottom electrode layer, besides — said piezo electric crystal layer and said top electrode layer — membrane formation — and, while carrying out patterning and forming said piezoelectric device The manufacture approach of the actuator equipment characterized by having the 2nd process used as the edge of the piezo electric crystal active section which forms the edge of said top electrode layer inside the edge of said bottom electrode layer, and turns into a substantial actuator of said piezoelectric device.

[Claim 11] The manufacture approach of the actuator equipment characterized by removing said field [/ near the edge of said bottom electrode layer of the piezoelectric device concerned] top electrode layer after forming each class which constitutes said piezoelectric device from said 2nd process in claim 10.

[Claim 12] The manufacture approach of the actuator equipment characterized by vapor-depositing said top electrode layer by mask vacuum evaporationo to fields other than a field [/ near said bottom electrode edge of said piezoelectric device on said piezo electric crystal layer] after forming said bottom electrode layer which constitutes said piezoelectric device from said 2nd process, and said piezo electric crystal layer in claim 10.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] By impressing an electrical potential difference to a piezoelectric-material layer, this invention constitutes a part of nozzle orifice which carries out the regurgitation of the ink droplet especially, and pressure generating room open for free passage from a diaphragm about the actuator equipment which has the piezoelectric device which carries out a variation rate, and its manufacture approach, and relates to the ink jet type recording head and ink jet type recording device which a piezoelectric device is formed [recording device] in the front face of this diaphragm, and make an ink droplet breathe out with the variation rate of a piezoelectric device.
[0002]
[Description of the Prior Art] A part of nozzle orifice which carries out the regurgitation of the ink droplet, and pressure generating room open for free passage are constituted from a diaphragm, and two kinds are put in practical use by the ink jet type recording head which makes this diaphragm transform by the piezoelectric device, and the ink of a pressure generating room is pressurized [recording head], and makes an ink droplet breathe out from a nozzle orifice although what used the electrostrictive actuator in the longitudinal-oscillation mode elongated and contracted, and the electrostrictive actuator in flexurally oscillating mode were used for the shaft orientations of a piezoelectric device.
[0003] The former can change the volume of a pressure generating room by making the end face of a piezoelectric device contact a diaphragm, and while the fabrication of the head suitable for high density printing is possible, a piezoelectric device is made in agreement with the array pitch of a nozzle orifice, the difficult process of carving in the shape of a ctenidium, and the activity which positions the piezoelectric device which was able to be carved in a pressure generating room, and is fixed are needed, and it has the problem that a production process is complicated.
[0004] On the other hand, the green sheet of piezoelectric material is stuck according to the configuration of a pressure generating room, a certain amount of area is needed for a diaphragm at the comparatively easy process of calcinating this, on the relation using flexural oscillation of what can fix a piezoelectric device, and the latter has the problem that a high density array is difficult.
[0005] On the other hand, that the inconvenience of the latter recording head should be canceled, what formed the piezoelectric device so that might continue on the surface of [whole] a diaphragm, a uniform piezoelectric-material layer might be formed with a membrane formation technique, this piezoelectric-material layer might be carved into the configuration corresponding to a pressure generating room by the lithography method and it might become independent for every pressure generating room is proposed so that JP,5-286131,A may see.
[0006] There is an advantage it not only can fix a piezoelectric device by the simple technique of the lithography method precisely, but that the activity which sticks a piezoelectric device on a diaphragm becomes unnecessary according to this, and can make thickness of a piezoelectric device thin and high-speed actuation is attained.
[0007] Moreover, although the piezoelectric device corresponding to each pressure generating room can be driven by preparing only a top electrode for every pressure generating room at least, preparing a piezoelectric-material layer on the surface of [whole] a diaphragm in this case As for

the piezo electric crystal layer which constitutes the piezo electric crystal active section from a problem of this stress to a piezo electric crystal layer in the part over the part which counters the amount of displacement and pressure generating room per unit driver voltage, and its exterior, and a top electrode, it is desirable to form so that it may not come out to pressure generating outdoor as much as possible.
[0008] Then, after carrying out patterning of the bottom electrode, while carrying out patterning and forming a piezoelectric device, membrane formation and the structure which installed the piezo electric crystal layer and the top electrode on the peripheral wall from the end section are proposed in the piezo electric crystal layer and the top electrode.
[0009]
[Problem(s) to be Solved by the Invention] However, with above-mentioned structure, on the bottom electrode by which patterning was usually carried out, in order to form a piezo electric crystal layer by a wet method or the sputtering methods, such as a sol-gel method, etc., the piezo electric crystal layer near the edge of a bottom electrode will be formed more thinly than other parts. When an electrical potential difference is impressed in this condition, field strength becomes large in a part with a thin piezo electric crystal layer, and there is a problem that dielectric breakdown will occur.
[0010] This invention makes it a technical problem to provide with an ink jet type recording head and an ink jet type recording device the actuator equipment which prevented dielectric breakdown of a piezo electric crystal layer and its manufacture approach, and a list in view of such a situation.

[0011]
[Means for Solving the Problem] The 1st mode of this invention which solves the above-mentioned technical problem The bottom electrode of a substrate established in the field through the insulating layer on the other hand, In the actuator equipment possessing the piezoelectric device which consists of an electrode after being prepared on the piezo electric crystal layer prepared on the bottom electrode of this, and this piezo electric crystal layer The edge of said top electrode is the edge of the piezo electric crystal active section which is located inside the edge of said bottom electrode and turns into a substantial actuator of said piezoelectric device. While constituting the piezo electric crystal non-activity section which said piezo electric crystal layer is prepared on said bottom electrode which projected outside the edge of said top electrode, and is not driven substantially, it is in the actuator equipment characterized by preparing said piezo electric crystal layer also in the outside of the edge of said bottom electrode.
[0012] In this 1st mode, the distance of the edge of the piezo electric crystal active section and the edge of a bottom electrode can be detached, and dielectric breakdown by electric-field concentration in the longitudinal direction edge of the piezo electric crystal active section is prevented.
[0013] In the 1st mode, while the 2nd mode of this invention is prepared in the field corresponding to the pressure generating room where said piezoelectric device was formed in said substrate, the edge of said piezo electric crystal active section is in the actuator equipment characterized by being located inside [circumferential corkscrew twist] said pressure generating interior of a room.
[0014] In this 2nd mode, actuation of the piezo electric crystal active section is not barred, and dielectric breakdown of a piezo electric crystal layer is prevented.
[0015] The 3rd mode of this invention is in the actuator equipment characterized by installing said piezo electric crystal layer to the same location as the edge of said bottom electrode, or its outside in the mode of the 1st or 2.
[0016] In this 3rd mode, a top electrode and a bottom electrode are insulated certainly and dielectric breakdown of the piezo electric crystal layer near the edge of a bottom electrode can prevent certainly.
[0017] the 4th mode of this invention — which 1-3rd voice — it is in the actuator equipment characterized by preparing the bottom electrode for wiring by which it sets like, and is prepared outside discontinuously [said bottom electrode] at the pan of the piezo electric crystal layer prepared in the outside of the edge of said bottom electrode, and an end is connected to external wiring for said every piezoelectric device.

[0018] In this 4th mode, a bottom electrode and the bottom electrode for wiring are certainly insulated by the piezo electric crystal layer, and wiring can be formed easily.
[0019] the 5th mode of this invention — which 1–4th voice — it sets like and is in the actuator equipment characterized by for said bottom electrode covering the piezoelectric device which plurality adjoins, and preparing it continuously.
[0020] In this 5th mode, the rigidity of a bottom electrode improves and endurance improves.
[0021] The 6th mode of this invention is in the actuator equipment characterized by carrying out patterning of said bottom electrode for every piezoelectric device in which 1–4th modes.
[0022] In this 6th mode, the amount of displacement by actuation of the piezo electric crystal active section improves.
[0023] the 7th mode of this invention — which 1–6th voice — it is in the ink jet type recording head characterized by joining the nozzle formation substrate which said substrate of actuator equipment [like] is a passage formation substrate which forms the pressure generating room which is open for free passage to a nozzle orifice, and has said nozzle orifice in the another side side side of this passage formation substrate.
[0024] In this 7th mode, the ink jet type recording head which can perform the good ink regurgitation from a nozzle orifice is realizable with actuation of a piezoelectric device.
[0025] The 8th mode of this invention is in the ink jet type recording head characterized by forming said pressure generating room in a silicon single crystal substrate of anisotropic etching, and forming each class of said piezoelectric device by the thin film and the lithography method in the 7th mode.
[0026] In this 8th mode, the ink jet type recording head which has the nozzle orifice of high density can be manufactured in large quantities and comparatively easily.
[0027] The 9th mode of this invention is in the ink jet type recording device characterized by providing the ink jet type recording head of the mode of the 7th or 8.
[0028] In this 9th mode, the ink jet type recording head which improved the dependability of a head is realizable.
[0029] On a substrate, the 10th mode of this invention carries out the laminating of a bottom electrode layer, a piezo electric crystal layer, and the top electrode layer one by one through an insulating layer, and carries out patterning of each class. In the formation approach of the piezoelectric device which forms the piezoelectric device which consists of said bottom electrode layer, said piezo electric crystal layer, and said top electrode layer The 1st process which forms the bottom electrode layer clearance section which carried out patterning and removed said bottom electrode layer while forming said bottom electrode layer, besides — said piezo electric crystal layer and said top electrode layer — membrane formation — and, while carrying out patterning and forming said piezoelectric device It is in the manufacture approach of the actuator equipment characterized by having the 2nd process used as the edge of the piezo electric crystal active section which forms the edge of said top electrode layer inside the edge of said bottom electrode layer, and turns into a substantial actuator of said piezoelectric device.
[0030] In this 10th mode, the piezo electric crystal active section can be formed comparatively easily.
[0031] The 11th mode of this invention is in the manufacture approach of the actuator equipment characterized by removing said field [/ near the edge of said bottom electrode layer of the piezoelectric device concerned] top electrode layer at said 2nd process in the 10th mode after forming each class which constitutes said piezoelectric device.
[0032] In this 11th mode, the piezo electric crystal non–activity section can be formed comparatively easily.
[0033] The 12th mode of this invention is in the manufacture approach of the actuator equipment characterized by vapor–depositing said top electrode layer by mask vacuum evaporationo to fields other than a field [/ near said bottom electrode edge of said piezoelectric device on said piezo electric crystal layer] at said 2nd process in the 10th mode after forming said bottom electrode layer which constitutes said piezoelectric device, and said piezo electric crystal layer.
[0034] In this 12th mode, the piezo electric crystal non–activity section can be formed comparatively easily.

[0035]
[Embodiment of the Invention] This invention is explained at a detail based on an operation gestalt below.
[0036] (Operation gestalt 1) Drawing 1 is the decomposition perspective view showing the ink jet type recording head concerning the operation gestalt 1 of this invention, and drawing 2 is the top view and a sectional view in the longitudinal direction of one pressure generating room.
[0037] The passage formation substrate 10 consists of a silicon single crystal substrate of field bearing (110) with this operation gestalt so that it may illustrate. As a passage formation substrate 10, a thing with a thickness of about 150–300 micrometers is used, and about 180–280 micrometers of things with a thickness of about 220 micrometers are usually more desirably suitable desirably. This is because an array consistency can be made high, maintaining the rigidity of the septum between adjoining pressure generating rooms.
[0038] One field of the passage formation substrate 10 turns into an effective area, and the elastic membrane 50 with a thickness of 1–2 micrometers which consists of diacid–ized silicon beforehand formed by thermal oxidation is formed in the field of another side.
[0039] On the other hand, the nozzle orifice 11 and the pressure generating room 12 are formed in the effective area of the passage formation substrate 10 by carrying out anisotropic etching of the silicon single crystal substrate.
[0040] If anisotropic etching is immersed in alkali solutions, such as a potassium hydroxide, a silicon single crystal substrate here It is eaten away gradually and nothing, and the above–mentioned (110) field and the 2nd field (111) which makes the include angle of about 35 degrees appear the 1st field (111) vertical to a field (110), this 1st field (111), and the include angle of about 70 degrees. (110) It is carried out using the property in which the etching rate of a field (111) is about 1/180 as compared with the etching rate of a field. By this anisotropic etching, precision processing can be performed on the basis of depth processing of the shape of the 1st two field (111) and a parallelogram formed in respect of [slanting / two] the 2nd (111), and the pressure generating room 12 can be arranged to high density.
[0041] The long side of each pressure generating room 12 is formed, and the shorter side is formed in respect of the 2nd (111) in respect of the 1st (111) with this operation gestalt. This pressure generating room 12 is formed by etching until it penetrates the passage formation substrate 10 mostly and reaches elastic membrane 50. In addition, elastic membrane 50 has the very small amount invaded by the alkali solution which etches a silicon single crystal substrate.
[0042] On the other hand, each nozzle orifice 11 which is open for free passage at the end of each pressure generating room 12 is formed more shallowly [narrow] than the pressure generating room 12. That is, the nozzle orifice 11 is formed by etching a silicon single crystal substrate in the thickness direction to the middle (half etching). In addition, half etching is performed by adjustment of etching time.
[0043] Here, the magnitude of the pressure generating room 12 which gives an expulsion–of–an–ink–droplet pressure to ink, and the magnitude of the nozzle orifice 11 which carries out the regurgitation of the ink droplet are optimized according to the amount of the ink droplet which carries out the regurgitation, regurgitation speed, and a regurgitation frequency. For example, when recording 360 ink droplets per inch, it is necessary to form a nozzle orifice 11 with a sufficient precision with the flute width of dozens of micrometers.
[0044] Moreover, each pressure generating room 12 and the common ink room 31 mentioned later are opened for free passage through the ink supply free passage opening 21 formed in the location corresponding to the end section of each pressure generating room 12 of the closure plate 20 mentioned later, respectively, and ink is supplied from the common ink room 31 through this ink supply free passage opening 21, and is distributed to each pressure generating room 12.
[0045] The closure plate 20 consists of crystallized glass with which the ink supply free passage opening 21 corresponding to each above–mentioned pressure generating room 12 was drilled and which thickness is 0.1–1mm, and coefficient of linear expansion is 300 degrees C or less, for example, is 2.5–4.5 [x10–6/degree C]. In addition, the ink supply free passage opening 21 may be two or more slit [A / which crosses near the ink supply side edge section of each pressure generating room 12 / one slit hole 21] hole 21B, as shown in drawing 3 (a) and (b). As for the

closure plate 20, the duty of the back up plate which protects a bonnet and a silicon single crystal substrate from an impact or external force extensively also achieves the whole surface of the passage formation substrate 10 in respect of one side. Moreover, on the other hand, the closure plate 20 comes out, and constitutes one wall surface of the common ink room 31.
[0046] The common ink room formation substrate 30 forms the peripheral wall of the common ink room 31, pierces the stainless plate of proper thickness according to nozzle numerical aperture and an expulsion-of-an-ink-droplet frequency, and is produced. With this operation gestalt, thickness of the common ink room formation substrate 30 is set to 0.2mm.
[0047] The ink room side plate 40 consists of a stainless steel substrate, and constitutes one wall surface of the common ink room 31 from one field. Moreover, by forming crevice 40a in a part of field of another side by half etching, a thin wall 41 is formed and blanking formation of the ink inlet 42 which receives the ink supply from the outside is carried out further at the ink room side plate 40. In addition, a thin wall 41 is for absorbing the nozzle orifice 11 generated in the case of expulsion of an ink droplet, and the pressure which goes to an opposite hand, and prevents that an unnecessary forward or negative pressure joins other pressure generating rooms 12 via the common ink room 31. Although the ink room side plate 40 is set to 0.2mm and the part is used as the thin wall 41 with a thickness of 0.02mm with this operation gestalt in consideration of rigidity required at the time of connection between the ink inlet 42 and an external ink supply means etc., in order to omit formation of the thin wall 41 by half etching, it is good also as 0.02mm from the start in the thickness of the ink room side plate 40.
[0048] On the other hand, with the effective area of the passage formation substrate 10, on the elastic membrane 50 of an opposite hand, laminating formation is carried out in the process which thickness mentions [thickness] later with the bottom electrode layer 60 which is about 0.5 micrometers, and the electrode layer 80 when it is about 0.1 micrometers mentions [the piezo electric crystal film 70 which is about 1 micrometer, and thickness] later, and the piezoelectric device 300 is constituted. Here, a piezoelectric device 300 says the part containing the bottom electrode layer 60, the piezo electric crystal film 70, and the top electrode layer 80. Generally, one electrode of the piezoelectric devices 300 is used as a common electrode, every pressure generating room 12, patterning of the electrode and the piezo electric crystal film 70 of another side is carried out, and they are constituted. And it consists of one of the electrodes and the piezo electric crystal film 70 by which patterning was carried out here, and the part which a piezo-electric distortion produces by impression of the electrical potential difference to two electrodes is called piezo electric crystal active section 320. Although the bottom electrode layer 60 considers as the common electrode of a piezoelectric device 300 and the top electrode layer 80 is used as the individual electrode of a piezoelectric device 300 with this operation gestalt, it is convenient even if it makes this into reverse on account of an actuation circuit or wiring. In the case of which, the piezo electric crystal active section will be formed for every pressure generating room. Moreover, the diaphragm which a variation rate produces by actuation of a piezoelectric device 300 and the piezoelectric device 300 concerned is set, and an electrostrictive actuator is called here.
[0049] Here, the process which forms piezo electric crystal film 70 grade on the passage formation substrate 10 which consists of a silicon single crystal substrate is explained, referring to drawing 4 - drawing 6 . In addition, drawing 4 and drawing 6 are the sectional views of the longitudinal direction of the pressure generating room 12, and drawing 5 R> 5 is the sectional view of the cross direction of the pressure generating room 12.
[0050] First, as shown in drawing 4 (a), the elastic membrane 50 which oxidizes thermally the wafer of the silicon single crystal substrate used as the passage formation substrate 10 with about 1100-degree C diffusion furnace, and consists of diacid-ized silicon is formed.
[0051] Next, as shown in drawing 4 (b), the bottom electrode layer 60 is formed by sputtering. As an ingredient of the bottom electrode layer 60, platinum, iridium, oxidization iridium, or these alloys are suitable. The below-mentioned piezo electric crystal film 70 which this forms by the sol-gel method or the sputtering method is because it is necessary to make it calcinate and crystallize at the temperature of about 600-1000 degrees C under an atmospheric-air ambient atmosphere or an oxygen ambient atmosphere after membrane formation. That is, when conductivity must be able to be held under such an elevated temperature and an oxidizing atmosphere and titanic-acid lead

zirconate (PZT) is especially used as piezo electric crystal film 70, as for the ingredient of the bottom electrode layer 60, it is desirable for there to be little conductive change by diffusion of lead oxide, and platinum, iridium, oxidization iridium, or these alloys are suitable for it from these reasons.

[0052] Next, as shown in drawing 4 (c), patterning of the bottom electrode layer 60 is carried out to a predetermined configuration every pressure generating room 12. That is, patterning of the bottom electrode layer 60 of the field which counters the peripheral wall of the longitudinal direction end section of the pressure generating room 12 is carried out, and the bottom electrode layer 61 for wiring which became independent corresponding to each pressure generating room 12, respectively is formed.

[0053] Next, as shown in drawing 4 (d), the piezo electric crystal film 70 is formed. With this operation gestalt, spreading desiccation was carried out, the so-called sol which dissolved and distributed the metal organic substance at the solvent was gelled, and it formed using the so-called sol-gel method which obtains the piezo electric crystal film 70 which consists of a metallic oxide by calcinating at an elevated temperature further. As an ingredient of the piezo electric crystal film 70, when the ingredient of a titanic-acid lead zirconate system uses it for an ink jet type recording head, it is suitable. In addition, especially the membrane formation approach of this piezo electric crystal film 70 is not limited, for example, may be formed by the sputtering method.

[0054] Furthermore, the approach of carrying out crystal growth at low temperature with the high voltage approach in the inside of an alkali water solution after forming the precursor film of titanic-acid lead zirconate by the sol-gel method or the sputtering method may be used.

[0055] Next, as shown in drawing 4 (e), the top electrode layer 80 is formed. The top electrode layer 80 can use a metal, a conductive oxide, etc. of many, such as aluminum, gold, nickel, and platinum, that what is necessary is just a conductive high ingredient. With this operation gestalt, platinum is formed by sputtering.

[0056] Then, as shown in drawing 5 (a), only the piezo electric crystal film 70 and the top electrode layer 80 are etched, and patterning of the piezo electric crystal active section 320 is performed. Subsequently, by etching the top electrode layer 80 near [by the side of the bottom electrode layer 61 for wiring of each piezo electric crystal active section 320] the edge, as shown in drawing 6 , although it has the piezo electric crystal film 70, the piezo electric crystal non-actuator 330 which does not drive substantially is formed in the edge of the piezo electric crystal active section 320. The above is a film formation process. Moreover, after doing in this way and performing film formation, as shown in drawing 5 (b), anisotropic etching of the silicon single crystal substrate by the alkali solution mentioned above is performed, and pressure generating room 12 grade is formed.

[0057] Thus, the important section flat surface and cross section of an ink jet type recording head which were formed are shown in drawing 7 .

[0058] As shown in drawing 7 , patterning of the piezo electric crystal film 70 which constitutes the piezo electric crystal active section 320, and the top electrode layer 80 is fundamentally carried out into each pressure generating room 12. On the other hand, the bottom electrode layer 60 is continued and formed in the field corresponding to two or more installed pressure generating rooms 12, and patterning is carried out by the inside of the field corresponding to the pressure generating room 12 at the longitudinal direction end section side of the pressure generating room 12.

[0059] Moreover, with this operation gestalt, the end section of the top electrode layer 80 is located inside the edge of the bottom electrode layer 60, and the edge of the top [this] electrode layer 80 is the edge of the piezo electric crystal active section 320. Moreover, although the piezo electric crystal film 70 is formed also on the bottom electrode layer 60 which the edge of the piezo electric crystal film 70 is the edge and abbreviation same location of the bottom electrode layer 60, and projected outside the edge of the top electrode layer 80, this part serves as the piezo electric crystal non-activity section 330 which is not driven substantially.

[0060] Moreover, patterning of the bottom electrode layer 60 on the peripheral wall of the pressure generating room 12 by the side of this piezo electric crystal non-activity section 330 is carried out independently every piezo electric crystal active section 320, and it is the bottom electrode layer

61 for wiring used as wiring of each piezo electric crystal active section 320. And the bottom electrode layer 61 for this wiring is connected with the piezo electric crystal active section 320 top electrode layer 80 through the lead electrode 100 installed on the piezo electric crystal non-activity section 330 while connecting with the external terminal which an end does not illustrate. In addition, into the part to which patterning of the bottom electrode layer 60 between the bottom electrode layer 61 for this wiring and the bottom electrode layer 60 was carried out, it remains with this operation gestalt, without removing the piezo electric crystal film 70, and the bottom electrode layer 60 and the lead electrode 100 are insulated.

[0061] Thus, with this operation gestalt, the piezo electric crystal non-activity section 330 was continuously formed in the edge outside by the side of the drawer of the lead electrode 100 of the piezo electric crystal active section 320 by removing the top electrode layer 80. Thereby, distance of the edge of the electrode layer 80 when it is the edge of the piezo electric crystal active section 320, and the edge of the bottom electrode layer 60 can be enlarged. For this reason, also by electrical-potential-difference impression to the piezo electric crystal active section 320, the field strength in the edge of the piezo electric crystal active section 320 does not become large, and dielectric breakdown of the piezo electric crystal film 70 etc. can be prevented. Moreover, since the thickness of the piezo electric crystal film 70 of the piezo electric crystal active section 320 becomes uniform, a piezo-electric property improves.

[0062] In addition, although considered as the piezo electric crystal non-activity section 330 with this operation gestalt by removing the longitudinal direction end section top electrode layer 80 after forming each class of the piezo electric crystal active section 320 By the so-called mask vacuum evaporationo which vapor-deposits the top electrode layer 80 where it was not limited to this approach, for example, the piezo electric crystal film 70 of a field [/ near the edge of the bottom electrode layer 60] is covered with a mask It is made not to vapor-deposit the top electrode layer 80 on the piezo electric crystal film 70 near the edge of the bottom electrode layer 60, and is good for it also considering this part as the piezo electric crystal non-activity section 330.

[0063] Moreover, although the edge of the piezo electric crystal film 70 was made into the same location as the edge of the bottom electrode layer 60, it is not limited to this but you may make it install further with this operation gestalt to an outside, for example, the field which counters the bottom electrode layer 61 for wiring.

[0064] Furthermore, although the piezoelectric device 300 which plurality adjoins is covered and the bottom electrode layer 60 was continuously formed with this operation gestalt, it is not limited to this, for example, patterning is carried out every piezoelectric device 300, and you may make it pull out from an opposite hand to the exterior with the drawer side of the lead electrode 100 of the pressure generating room 12. In this case, as shown in drawing 8 (a), as shown in drawing 8 R> 8 (b), the bottom electrode layer 61 for wiring prepared every piezoelectric device 300 is connected, and it is good [the bottom electrode layer 60 pulled out from each pressure generating room 12 is connected on a peripheral wall, and it is good also as a common electrode, or] as a common electrode also considering the bottom electrode layer 60 as an individual electrode of each piezoelectric device 300.

[0065] Moreover, when patterning of the bottom electrode layer 60 is carried out every piezoelectric device 300 in this way, the piezo electric crystal film 70 is formed by width of face larger than the bottom electrode layer 60, and you may make it cover the side face of the crosswise ends of the bottom electrode layer 60 by the piezo electric crystal film 70.

[0066] By a series of film formation of the piezo electric crystal active section 320 explained above and pressure generating room 12 grade, and anisotropic etching, much chips are simultaneously formed on one wafer, and it divides after process termination every passage formation substrate 10 of one chip size as shown in drawing 1 . Moreover, sequential adhesion is carried out with the closure plate 20, the common ink room formation substrate 30, and the ink room side plate 40, and it unifies, and let the divided passage formation substrate 10 be an ink jet type recording head.

[0067] Moreover, the ink jet head constituted in this way Ink is incorporated from the ink inlet 42 linked to the external ink supply means which is not illustrated. After filling the interior with ink until it results [from the common ink room 31] in a nozzle orifice 11, By impressing an electrical

potential difference between the top electrode layer 80 and the bottom electrode layer 60, and carrying out deflection deformation of elastic membrane 50, the bottom electrode layer 60, and the piezo electric crystal film 70 according to the record signal from the actuation circuit of the exterior which is not illustrated, the pressure in the pressure generating room 12 increases, and an ink droplet carries out the regurgitation from a nozzle orifice 11.

[0068] (Other operation gestalten) Although each operation gestalt of this invention was explained above, the fundamental configuration of an ink jet type recording head is not limited to what was mentioned above.

[0069] For example, it is good also considering the common ink room formation plate 30 besides the closure plate 20 mentioned above as a product made from crystallized glass, and it is still better also as a product made from crystallized glass, using the light-gage film 41 as another member, and modification of an ingredient, structure, etc. is free.

[0070] Moreover, with the operation gestalt mentioned above, although the nozzle orifice is formed in the end face of the passage formation substrate 10, the nozzle orifice which projects in the direction vertical to a field may be formed.

[0071] Thus, it is ********** to drawing 10 about the cross section of drawing 9 and its passage in the decomposition perspective view of the constituted operation gestalt. With this operation gestalt, a nozzle orifice 11 is drilled by the reverse nozzle formation substrate 120 with a piezoelectric device, and the nozzle free passage opening 22 which opens these nozzle orifices 11 and the pressure generating room 12 for free passage is arranged so that the closure plate 20, the common ink room formation plate 30, light-gage plate 41A, and ink room side plate 40A may be penetrated.

[0072] In addition, it is the same as that of the operation gestalt fundamentally mentioned above except this operation gestalt having, used light-gage plate 41A and ink room side plate 40A as another member in addition to this, and having formed opening 40b in ink room side plate 40A, and the explanation which gives the same sign to the same member and overlaps is omitted.

[0073] Of course, it cannot be overemphasized by combining suitably each operation gestalt explained above, and carrying out that it is what does much more effectiveness so.

[0074] Moreover, although each operation gestalt explained above made the example the ink jet type recording head of the thin film mold which can be manufactured by applying membrane formation and a lithography process Not the thing limited to this, of course but the thing which carries out the laminating of the substrate and forms a pressure generating room, Or this invention is employable as the ink jet type recording head of various kinds of structures, such as what forms the piezo electric crystal film with crystal growth, such as a thing which forms the piezo electric crystal film for a green sheet by pasting or screen-stencil, or a hydrothermal method.

[0075] Thus, this invention is applicable to the ink jet type recording head of various structures, unless it is contrary to the meaning.

[0076] Moreover, the ink jet type recording head of each [these] operation gestalt constitutes some recording head units possessing an ink cartridge etc. and ink passage open for free passage, and is carried in an ink jet type recording device. Drawing 11 is the schematic diagram showing an example of the ink jet type recording device.

[0077] As shown in drawing 11 , the carriage 3 which was formed removable and carried these recording head units 1A and 1B is formed free [shaft-orientations migration on the carriage shaft 5 with which cartridge 2A and 2B from which the recording head units 1A and 1B which have an ink jet type recording head constitute an ink supply means were attached in the body 4 of equipment]. These recording head units 1A and 1B shall carry out the regurgitation of a black ink constituent and the color ink constituent, respectively, for example.

[0078] And the carriage 3 carrying the recording head units 1A and 1B is moved in accordance with the carriage shaft 5 by being transmitted to carriage 3 through two or more gearings and timing belts 7 which the driving force of a drive motor 6 does not illustrate. On the other hand, along with carriage 3, the platen 8 is formed in the body 4 of equipment. Record sheet S which is record media, such as paper to which can rotate now with the driving force of the paper feed motor which is not illustrated, and paper was fed with the feed roller etc., winds this platen 8 around a platen 8, it is hung, and is conveyed.

[0079]
[Effect of the Invention] As explained above, in this invention, the piezo electric crystal non-activity section which does not have a top electrode layer for the edge of a top electrode layer as the inside [edge / of a bottom electrode layer] in the longitudinal direction end section side of the piezo electric crystal active section is prepared, and the distance of the edge of the piezo electric crystal active section and the edge of a bottom electrode layer was detached. Thereby, dielectric breakdown near the edge of the piezo electric crystal active section can be prevented, and endurance and dependability can be improved.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] By impressing an electrical potential difference to a piezoelectric-material layer, this invention constitutes a part of nozzle orifice which carries out the regurgitation of the ink droplet especially, and pressure generating room open for free passage from a diaphragm about the actuator equipment which has the piezoelectric device which carries out a variation rate, and its manufacture approach, and relates to the ink jet type recording head and ink jet type recording device which a piezoelectric device is formed [recording device] in the front face of this diaphragm, and make an ink droplet breathe out with the variation rate of a piezoelectric device.

[Translation done.]

PRIOR ART

[Description of the Prior Art] A part of nozzle orifice which carries out the regurgitation of the ink droplet, and pressure generating room open for free passage are constituted from a diaphragm, and two kinds are put in practical use by the ink jet type recording head which makes this diaphragm transform by the piezoelectric device, and the ink of a pressure generating room is pressurized [recording head], and makes an ink droplet breathe out from a nozzle orifice although what used the electrostrictive actuator in the longitudinal-oscillation mode elongated and contracted, and the electrostrictive actuator in flexurally oscillating mode were used for the shaft orientations of a piezoelectric device.

[0003] The former can change the volume of a pressure generating room by making the end face of a piezoelectric device contact a diaphragm, and while the fabrication of the head suitable for high density printing is possible, a piezoelectric device is made in agreement with the array pitch of a nozzle orifice, the difficult process of carving in the shape of a ctenidium, and the activity which positions the piezoelectric device which was able to be carved in a pressure generating room, and is fixed are needed, and it has the problem that a production process is complicated.

[0004] On the other hand, the green sheet of piezoelectric material is stuck according to the configuration of a pressure generating room, a certain amount of area is needed for a diaphragm at the comparatively easy process of calcinating this, on the relation using flexural oscillation of what can fix a piezoelectric device, and the latter has the problem that a high density array is difficult.

[0005] On the other hand, that the inconvenience of the latter recording head should be canceled, what formed the piezoelectric device so that might continue on the surface of [whole] a diaphragm, a uniform piezoelectric-material layer might be formed with a membrane formation technique, this piezoelectric-material layer might be carved into the configuration corresponding to a pressure generating room by the lithography method and it might become independent for every pressure generating room is proposed so that JP,5-286131,A may see.

[0006] There is an advantage it not only can fix a piezoelectric device by the simple technique of the lithography method precisely, but that the activity which sticks a piezoelectric device on a diaphragm becomes unnecessary according to this, and can make thickness of a piezoelectric device thin and high-speed actuation is attained.

[0007] Moreover, although the piezoelectric device corresponding to each pressure generating room can be driven by preparing only a top electrode for every pressure generating room at least, preparing a piezoelectric-material layer on the surface of [whole] a diaphragm in this case As for the piezo electric crystal layer which constitutes the piezo electric crystal active section from a problem of this stress to a piezo electric crystal layer in the part over the part which counters the amount of displacement and pressure generating room per unit driver voltage, and its exterior, and a top electrode, it is desirable to form so that it may not come out to pressure generating outdoor as much as possible.

[0008] Then, after carrying out patterning of the bottom electrode, while carrying out patterning and forming a piezoelectric device, membrane formation and the structure which installed the piezo electric crystal layer and the top electrode on the peripheral wall from the end section are proposed in the piezo electric crystal layer and the top electrode.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, in this invention, the piezo electric crystal non-activity section which does not have a top electrode layer for the edge of a top electrode layer as the inside [edge / of a bottom electrode layer] in the longitudinal direction end section side of the piezo electric crystal active section is prepared, and the distance of the edge of the piezo electric crystal active section and the edge of a bottom electrode layer was detached. Thereby, dielectric breakdown near the edge of the piezo electric crystal active section can be prevented, and endurance and dependability can be improved.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, with above-mentioned structure, on the bottom electrode by which patterning was usually carried out, in order to form a piezo electric crystal layer by a wet method or the sputtering methods, such as a sol-gel method, etc., the piezo electric crystal layer near the edge of a bottom electrode will be formed more thinly than other parts. When an electrical potential difference is impressed in this condition, field strength becomes large in a part with a thin piezo electric crystal layer, and there is a problem that dielectric breakdown will occur.
[0010] This invention makes it a technical problem to provide with an ink jet type recording head and an ink jet type recording device the actuator equipment which prevented dielectric breakdown of a piezo electric crystal layer and its manufacture approach, and a list in view of such a situation.

[Translation done.]

MEANS

[Means for Solving the Problem] The 1st mode of this invention which solves the above-mentioned technical problem The bottom electrode of a substrate established in the field through the insulating layer on the other hand, In the actuator equipment possessing the piezoelectric device which consists of an electrode after being prepared on the piezo electric crystal layer prepared on the bottom electrode of this, and this piezo electric crystal layer The edge of said top electrode is the edge of the piezo electric crystal active section which is located inside the edge of said bottom electrode and turns into a substantial actuator of said piezoelectric device. While constituting the piezo electric crystal non-activity section which said piezo electric crystal layer is prepared on said bottom electrode which projected outside the edge of said top electrode, and is not driven substantially, it is in the actuator equipment characterized by preparing said piezo electric crystal layer also in the outside of the edge of said bottom electrode.
[0012] In this 1st mode, the distance of the edge of the piezo electric crystal active section and the edge of a bottom electrode can be detached, and dielectric breakdown by electric-field concentration in the longitudinal direction edge of the piezo electric crystal active section is prevented.
[0013] In the 1st mode, while the 2nd mode of this invention is prepared in the field corresponding to the pressure generating room where said piezoelectric device was formed in said substrate, the edge of said piezo electric crystal active section is in the actuator equipment characterized by being located inside [circumferential corkscrew twist] said pressure generating interior of a room.
[0014] In this 2nd mode, actuation of the piezo electric crystal active section is not barred, and dielectric breakdown of a piezo electric crystal layer is prevented.
[0015] The 3rd mode of this invention is in the actuator equipment characterized by installing said piezo electric crystal layer to the same location as the edge of said bottom electrode, or its outside in the mode of the 1st or 2.
[0016] In this 3rd mode, a top electrode and a bottom electrode are insulated certainly and dielectric breakdown of the piezo electric crystal layer near the edge of a bottom electrode can prevent certainly.
[0017] the 4th mode of this invention — which 1-3rd voice — it is in the actuator equipment characterized by preparing the bottom electrode for wiring by which it sets like, and is prepared outside discontinuously [said bottom electrode] at the pan of the piezo electric crystal layer prepared in the outside of the edge of said bottom electrode, and an end is connected to external wiring for said every piezoelectric device.
[0018] In this 4th mode, a bottom electrode and the bottom electrode for wiring are certainly insulated by the piezo electric crystal layer, and wiring can be formed easily.
[0019] the 5th mode of this invention — which 1-4th voice — it sets like and is in the actuator equipment characterized by for said bottom electrode covering the piezoelectric device which plurality adjoins, and preparing it continuously.
[0020] In this 5th mode, the rigidity of a bottom electrode improves and endurance improves.
[0021] The 6th mode of this invention is in the actuator equipment characterized by carrying out patterning of said bottom electrode for every piezoelectric device in which 1-4th modes.
[0022] In this 6th mode, the amount of displacement by actuation of the piezo electric crystal

active section improves.
[0023] the 7th mode of this invention — which 1–6th voice — it is in the ink jet type recording head characterized by joining the nozzle formation substrate which said substrate of actuator equipment [like] is a passage formation substrate which forms the pressure generating room which is open for free passage to a nozzle orifice, and has said nozzle orifice in the another side side side of this passage formation substrate.
[0024] In this 7th mode, the ink jet type recording head which can perform the good ink regurgitation from a nozzle orifice is realizable with actuation of a piezoelectric device.
[0025] The 8th mode of this invention is in the ink jet type recording head characterized by forming said pressure generating room in a silicon single crystal substrate of anisotropic etching, and forming each class of said piezoelectric device by the thin film and the lithography method in the 7th mode.
[0026] In this 8th mode, the ink jet type recording head which has the nozzle orifice of high density can be manufactured in large quantities and comparatively easily.
[0027] The 9th mode of this invention is in the ink jet type recording device characterized by providing the ink jet type recording head of the mode of the 7th or 8.
[0028] In this 9th mode, the ink jet type recording head which improved the dependability of a head is realizable.
[0029] On a substrate, the 10th mode of this invention carries out the laminating of a bottom electrode layer, a piezo electric crystal layer, and the top electrode layer one by one through an insulating layer, and carries out patterning of each class. In the formation approach of the piezoelectric device which forms the piezoelectric device which consists of said bottom electrode layer, said piezo electric crystal layer, and said top electrode layer The 1st process which forms the bottom electrode layer clearance section which carried out patterning and removed said bottom electrode layer while forming said bottom electrode layer, besides — said piezo electric crystal layer and said top electrode layer — membrane formation — and, while carrying out patterning and forming said piezoelectric device It is in the manufacture approach of the actuator equipment characterized by having the 2nd process used as the edge of the piezo electric crystal active section which forms the edge of said top electrode layer inside the edge of said bottom electrode layer, and turns into a substantial actuator of said piezoelectric device.
[0030] In this 10th mode, the piezo electric crystal active section can be formed comparatively easily.
[0031] The 11th mode of this invention is in the manufacture approach of the actuator equipment characterized by removing said field [/ near the edge of said bottom electrode layer of the piezoelectric device concerned] top electrode layer at said 2nd process in the 10th mode after forming each class which constitutes said piezoelectric device.
[0032] In this 11th mode, the piezo electric crystal non–activity section can be formed comparatively easily.
[0033] The 12th mode of this invention is in the manufacture approach of the actuator equipment characterized by vapor–depositing said top electrode layer by mask vacuum evaporationo to fields other than a field [/ near said bottom electrode edge of said piezoelectric device on said piezo electric crystal layer] at said 2nd process in the 10th mode after forming said bottom electrode layer which constitutes said piezoelectric device, and said piezo electric crystal layer.
[0034] In this 12th mode, the piezo electric crystal non–activity section can be formed comparatively easily.
[0035]
[Embodiment of the Invention] This invention is explained at a detail based on an operation gestalt below.
[0036] (Operation gestalt 1) Drawing 1 is the decomposition perspective view showing the ink jet type recording head concerning the operation gestalt 1 of this invention, and drawing 2 is the top view and a sectional view in the longitudinal direction of one pressure generating room.
[0037] The passage formation substrate 10 consists of a silicon single crystal substrate of field bearing (110) with this operation gestalt so that it may illustrate. As a passage formation substrate 10, a thing with a thickness of about 150–300 micrometers is used, and about 180–280

micrometers of things with a thickness of about 220 micrometers are usually more desirably suitable desirably. This is because an array consistency can be made high, maintaining the rigidity of the septum between adjoining pressure generating rooms.
[0038] One field of the passage formation substrate 10 turns into an effective area, and the elastic membrane 50 with a thickness of 1-2 micrometers which consists of diacid-ized silicon beforehand formed by thermal oxidation is formed in the field of another side.
[0039] On the other hand, the nozzle orifice 11 and the pressure generating room 12 are formed in the effective area of the passage formation substrate 10 by carrying out anisotropic etching of the silicon single crystal substrate.
[0040] If anisotropic etching is immersed in alkali solutions, such as a potassium hydroxide, a silicon single crystal substrate here It is eaten away gradually and nothing, and the above-mentioned (110) field and the 2nd field (111) which makes the include angle of about 35 degrees appear the 1st field (111) vertical to a field (110), this 1st field (111), and the include angle of about 70 degrees. (110) It is carried out using the property in which the etching rate of a field (111) is about 1/180 as compared with the etching rate of a field. By this anisotropic etching, precision processing can be performed on the basis of depth processing of the shape of the 1st two field (111) and a parallelogram formed in respect of [slanting / two] the 2nd (111), and the pressure generating room 12 can be arranged to high density.
[0041] The long side of each pressure generating room 12 is formed, and the shorter side is formed in respect of the 2nd (111) in respect of the 1st (111) with this operation gestalt. This pressure generating room 12 is formed by etching until it penetrates the passage formation substrate 10 mostly and reaches elastic membrane 50. In addition, elastic membrane 50 has the very small amount invaded by the alkali solution which etches a silicon single crystal substrate.
[0042] On the other hand, each nozzle orifice 11 which is open for free passage at the end of each pressure generating room 12 is formed more shallowly [narrow] than the pressure generating room 12. That is, the nozzle orifice 11 is formed by etching a silicon single crystal substrate in the thickness direction to the middle (half etching). In addition, half etching is performed by adjustment of etching time.
[0043] Here, the magnitude of the pressure generating room 12 which gives an expulsion-of-an-ink-droplet pressure to ink, and the magnitude of the nozzle orifice 11 which carries out the regurgitation of the ink droplet are optimized according to the amount of the ink droplet which carries out the regurgitation, regurgitation speed, and a regurgitation frequency. For example, when recording 360 ink droplets per inch, it is necessary to form a nozzle orifice 11 with a sufficient precision with the flute width of dozens of micrometers.
[0044] Moreover, each pressure generating room 12 and the common ink room 31 mentioned later are opened for free passage through the ink supply free passage opening 21 formed in the location corresponding to the end section of each pressure generating room 12 of the closure plate 20 mentioned later, respectively, and ink is supplied from the common ink room 31 through this ink supply free passage opening 21, and is distributed to each pressure generating room 12.
[0045] The closure plate 20 consists of crystallized glass with which the ink supply free passage opening 21 corresponding to each above-mentioned pressure generating room 12 was drilled and which thickness is 0.1-1mm, and coefficient of linear expansion is 300 degrees C or less, for example, is 2.5-4.5 [x10-6/degree C]. In addition, the ink supply free passage opening 21 may be two or more slit [A / which crosses near the ink supply side edge section of each pressure generating room 12 / one slit hole 21] hole 21B, as shown in drawing 3 (a) and (b). As for the closure plate 20, the duty of the back up plate which protects a bonnet and a silicon single crystal substrate from an impact or external force extensively also achieves the whole surface of the passage formation substrate 10 in respect of one side. Moreover, on the other hand, the closure plate 20 comes out, and constitutes one wall surface of the common ink room 31.
[0046] The common ink room formation substrate 30 forms the peripheral wall of the common ink room 31, pierces the stainless plate of proper thickness according to nozzle numerical aperture and an expulsion-of-an-ink-droplet frequency, and is produced. With this operation gestalt, thickness of the common ink room formation substrate 30 is set to 0.2mm.
[0047] The ink room side plate 40 consists of a stainless steel substrate, and constitutes one wall

surface of the common ink room 31 from one field. Moreover, by forming crevice 40a in a part of field of another side by half etching, a thin wall 41 is formed and blanking formation of the ink inlet 42 which receives the ink supply from the outside is carried out further at the ink room side plate 40. In addition, a thin wall 41 is for absorbing the nozzle orifice 11 generated in the case of expulsion of an ink droplet, and the pressure which goes to an opposite hand, and prevents that an unnecessary forward or negative pressure joins other pressure generating rooms 12 via the common ink room 31. Although the ink room side plate 40 is set to 0.2mm and the part is used as the thin wall 41 with a thickness of 0.02mm with this operation gestalt in consideration of rigidity required at the time of connection between the ink inlet 42 and an external ink supply means etc., in order to omit formation of the thin wall 41 by half etching, it is good also as 0.02mm from the start in the thickness of the ink room side plate 40.

[0048] On the other hand, with the effective area of the passage formation substrate 10, on the elastic membrane 50 of an opposite hand, laminating formation is carried out in the process which thickness mentions [thickness] later with the bottom electrode layer 60 which is about 0.5 micrometers, and the electrode layer 80 when it is about 0.1 micrometers mentions [the piezo electric crystal film 70 which is about 1 micrometer, and thickness] later, and the piezoelectric device 300 is constituted. Here, a piezoelectric device 300 says the part containing the bottom electrode layer 60, the piezo electric crystal film 70, and the top electrode layer 80. Generally, one electrode of the piezoelectric devices 300 is used as a common electrode, every pressure generating room 12, patterning of the electrode and the piezo electric crystal film 70 of another side is carried out, and they are constituted. And it consists of one of the electrodes and the piezo electric crystal film 70 by which patterning was carried out here, and the part which a piezo-electric distortion produces by impression of the electrical potential difference to two electrodes is called piezo electric crystal active section 320. Although the bottom electrode layer 60 considers as the common electrode of a piezoelectric device 300 and the top electrode layer 80 is used as the individual electrode of a piezoelectric device 300 with this operation gestalt, it is convenient even if it makes this into reverse on account of an actuation circuit or wiring. In the case of which, the piezo electric crystal active section will be formed for every pressure generating room. Moreover, the diaphragm which a variation rate produces by actuation of a piezoelectric device 300 and the piezoelectric device 300 concerned is set, and an electrostrictive actuator is called here.

[0049] Here, the process which forms piezo electric crystal film 70 grade on the passage formation substrate 10 which consists of a silicon single crystal substrate is explained, referring to drawing 4 - drawing 6 . In addition, drawing 4 and drawing 6 are the sectional views of the longitudinal direction of the pressure generating room 12, and drawing 5 R> 5 is the sectional view of the cross direction of the pressure generating room 12.

[0050] First, as shown in drawing 4 (a), the elastic membrane 50 which oxidizes thermally the wafer of the silicon single crystal substrate used as the passage formation substrate 10 with about 1100-degree C diffusion furnace, and consists of diacid-ized silicon is formed.

[0051] Next, as shown in drawing 4 (b), the bottom electrode layer 60 is formed by sputtering. As an ingredient of the bottom electrode layer 60, platinum, iridium, oxidization iridium, or these alloys are suitable. The below-mentioned piezo electric crystal film 70 which this forms by the sol-gel method or the sputtering method is because it is necessary to make it calcinate and crystallize at the temperature of about 600-1000 degrees C under an atmospheric-air ambient atmosphere or an oxygen ambient atmosphere after membrane formation. That is, when conductivity must be able to be held under such an elevated temperature and an oxidizing atmosphere and titanic-acid lead zirconate (PZT) is especially used as piezo electric crystal film 70, as for the ingredient of the bottom electrode layer 60, it is desirable for there to be little conductive change by diffusion of lead oxide, and platinum, iridium, oxidization iridium, or these alloys are suitable for it from these reasons.

[0052] Next, as shown in drawing 4 (c), patterning of the bottom electrode layer 60 is carried out to a predetermined configuration every pressure generating room 12. That is, patterning of the bottom electrode layer 60 of the field which counters the peripheral wall of the longitudinal direction end section of the pressure generating room 12 is carried out, and the bottom electrode layer 61 for wiring which became independent corresponding to each pressure generating room 12,

respectively is formed.
[0053] Next, as shown in drawing 4 (d), the piezo electric crystal film 70 is formed. With this operation gestalt, spreading desiccation was carried out, the so-called sol which dissolved and distributed the metal organic substance at the solvent was gelled, and it formed using the so-called sol-gel method which obtains the piezo electric crystal film 70 which consists of a metallic oxide by calcinating at an elevated temperature further. As an ingredient of the piezo electric crystal film 70, when the ingredient of a titanic-acid lead zirconate system uses it for an ink jet type recording head, it is suitable. In addition, especially the membrane formation approach of this piezo electric crystal film 70 is not limited, for example, may be formed by the sputtering method.
[0054] Furthermore, the approach of carrying out crystal growth at low temperature with the high voltage approach in the inside of an alkali water solution after forming the precursor film of titanic-acid lead zirconate by the sol-gel method or the sputtering method may be used.
[0055] Next, as shown in drawing 4 (e), the top electrode layer 80 is formed. The top electrode layer 80 can use a metal, a conductive oxide, etc. of many, such as aluminum, gold, nickel, and platinum, that what is necessary is just a conductive high ingredient. With this operation gestalt, platinum is formed by sputtering.
[0056] Then, as shown in drawing 5 (a), only the piezo electric crystal film 70 and the top electrode layer 80 are etched, and patterning of the piezo electric crystal active section 320 is performed. Subsequently, by etching the top electrode layer 80 near [by the side of the bottom electrode layer 61 for wiring of each piezo electric crystal active section 320] the edge, as shown in drawing 6 , although it has the piezo electric crystal film 70, the piezo electric crystal non-actuator 330 which does not drive substantially is formed in the edge of the piezo electric crystal active section 320. The above is a film formation process. Moreover, after doing in this way and performing film formation, as shown in drawing 5 (b), anisotropic etching of the silicon single crystal substrate by the alkali solution mentioned above is performed, and pressure generating room 12 grade is formed.

[0057] Thus, the important section flat surface and cross section of an ink jet type recording head which were formed are shown in drawing 7 .
[0058] As shown in drawing 7 , patterning of the piezo electric crystal film 70 which constitutes the piezo electric crystal active section 320, and the top electrode layer 80 is fundamentally carried out into each pressure generating room 12. On the other hand, the bottom electrode layer 60 is continued and formed in the field corresponding to two or more installed pressure generating rooms 12, and patterning is carried out by the inside of the field corresponding to the pressure generating room 12 at the longitudinal direction end section side of the pressure generating room 12.
[0059] Moreover, with this operation gestalt, the end section of the top electrode layer 80 is located inside the edge of the bottom electrode layer 60, and the edge of the top [this] electrode layer 80 is the edge of the piezo electric crystal active section 320. Moreover, although the piezo electric crystal film 70 is formed also on the bottom electrode layer 60 which the edge of the piezo electric crystal film 70 is the edge and abbreviation same location of the bottom electrode layer 60, and projected outside the edge of the top electrode layer 80, this part serves as the piezo electric crystal non-activity section 330 which is not driven substantially.
[0060] Moreover, patterning of the bottom electrode layer 60 on the peripheral wall of the pressure generating room 12 by the side of this piezo electric crystal non-activity section 330 is carried out independently every piezo electric crystal active section 320, and it is the bottom electrode layer 61 for wiring used as wiring of each piezo electric crystal active section 320. And the bottom electrode layer 61 for this wiring is connected with the piezo electric crystal active section 320 top electrode layer 80 through the lead electrode 100 installed on the piezo electric crystal non-activity section 330 while connecting with the external terminal which an end does not illustrate. In addition, into the part to which patterning of the bottom electrode layer 60 between the bottom electrode layer 61 for this wiring and the bottom electrode layer 60 was carried out, it remains with this operation gestalt, without removing the piezo electric crystal film 70, and the bottom electrode layer 60 and the lead electrode 100 are insulated.
[0061] Thus, with this operation gestalt, the piezo electric crystal non-activity section 330 was

continuously formed in the edge outside by the side of the drawer of the lead electrode 100 of the piezo electric crystal active section 320 by removing the top electrode layer 80. Thereby, distance of the edge of the electrode layer 80 when it is the edge of the piezo electric crystal active section 320, and the edge of the bottom electrode layer 60 can be enlarged. For this reason, also by electrical-potential-difference impression to the piezo electric crystal active section 320, the field strength in the edge of the piezo electric crystal active section 320 does not become large, and dielectric breakdown of the piezo electric crystal film 70 etc. can be prevented. Moreover, since the thickness of the piezo electric crystal film 70 of the piezo electric crystal active section 320 becomes uniform, a piezo-electric property improves.

[0062] In addition, although considered as the piezo electric crystal non-activity section 330 with this operation gestalt by removing the longitudinal direction end section top electrode layer 80 after forming each class of the piezo electric crystal active section 320 By the so-called mask vacuum evaporationo which vapor-deposits the top electrode layer 80 where it was not limited to this approach, for example, the piezo electric crystal film 70 of a field [/ near the edge of the bottom electrode layer 60] is covered with a mask It is made not to vapor-deposit the top electrode layer 80 on the piezo electric crystal film 70 near the edge of the bottom electrode layer 60, and is good for it also considering this part as the piezo electric crystal non-activity section 330.

[0063] Moreover, although the edge of the piezo electric crystal film 70 was made into the same location as the edge of the bottom electrode layer 60, it is not limited to this but you may make it install further with this operation gestalt to an outside, for example, the field which counters the bottom electrode layer 61 for wiring.

[0064] Furthermore, although the piezoelectric device 300 which plurality adjoins is covered and the bottom electrode layer 60 was continuously formed with this operation gestalt, it is not limited to this, for example, patterning is carried out every piezoelectric device 300, and you may make it pull out from an opposite hand to the exterior with the drawer side of the lead electrode 100 of the pressure generating room 12. In this case, as shown in drawing 8 (a), as shown in drawing 8 R> 8 (b), the bottom electrode layer 61 for wiring prepared every piezoelectric device 300 is connected, and it is good [the bottom electrode layer 60 pulled out from each pressure generating room 12 is connected on a peripheral wall, and it is good also as a common electrode, or] as a common electrode also considering the bottom electrode layer 60 as an individual electrode of each piezoelectric device 300.

[0065] Moreover, when patterning of the bottom electrode layer 60 is carried out every piezoelectric device 300 in this way, the piezo electric crystal film 70 is formed by width of face larger than the bottom electrode layer 60, and you may make it cover the side face of the crosswise ends of the bottom electrode layer 60 by the piezo electric crystal film 70.

[0066] By a series of film formation of the piezo electric crystal active section 320 explained above and pressure generating room 12 grade, and anisotropic etching, much chips are simultaneously formed on one wafer, and it divides after process termination every passage formation substrate 10 of one chip size as shown in drawing 1 . Moreover, sequential adhesion is carried out with the closure plate 20, the common ink room formation substrate 30, and the ink room side plate 40, and it unifies, and let the divided passage formation substrate 10 be an ink jet type recording head.

[0067] Moreover, the ink jet head constituted in this way Ink is incorporated from the ink inlet 42 linked to the external ink supply means which is not illustrated. After filling the interior with ink until it results [from the common ink room 31] in a nozzle orifice 11, By impressing an electrical potential difference between the top electrode layer 80 and the bottom electrode layer 60, and carrying out deflection deformation of elastic membrane 50, the bottom electrode layer 60, and the piezo electric crystal film 70 according to the record signal from the actuation circuit of the exterior which is not illustrated, the pressure in the pressure generating room 12 increases, and an ink droplet carries out the regurgitation from a nozzle orifice 11.

[0068] (Other operation gestalten) Although each operation gestalt of this invention was explained above, the fundamental configuration of an ink jet type recording head is not limited to what was mentioned above.

[0069] For example, it is good also considering the common ink room formation plate 30 besides

the closure plate 20 mentioned above as a product made from crystallized glass, and it is still better also as a product made from crystallized glass, using the light-gage film 41 as another member, and modification of an ingredient, structure, etc. is free.
[0070] Moreover, with the operation gestalt mentioned above, although the nozzle orifice is formed in the end face of the passage formation substrate 10, the nozzle orifice which projects in the direction vertical to a field may be formed.
[0071] Thus, it is ********** to drawing 10 about the cross section of drawing 9 and its passage in the decomposition perspective view of the constituted operation gestalt. With this operation gestalt, a nozzle orifice 11 is drilled by the reverse nozzle formation substrate 120 with a piezoelectric device, and the nozzle free passage opening 22 which opens these nozzle orifices 11 and the pressure generating room 12 for free passage is arranged so that the closure plate 20, the common ink room formation plate 30, light-gage plate 41A, and ink room side plate 40A may be penetrated.
[0072] In addition, it is the same as that of the operation gestalt fundamentally mentioned above except this operation gestalt having, used light-gage plate 41A and ink room side plate 40A as another member in addition to this, and having formed opening 40b in ink room side plate 40A, and the explanation which gives the same sign to the same member and overlaps is omitted.
[0073] Of course, it cannot be overemphasized by combining suitably each operation gestalt explained above, and carrying out that it is what does much more effectiveness so.
[0074] Moreover, although each operation gestalt explained above made the example the ink jet type recording head of the thin film mold which can be manufactured by applying membrane formation and a lithography process Not the thing limited to this, of course but the thing which carries out the laminating of the substrate and forms a pressure generating room, Or this invention is employable as the ink jet type recording head of various kinds of structures, such as what forms the piezo electric crystal film with crystal growth, such as a thing which forms the piezo electric crystal film for a green sheet by pasting or screen-stencil, or a hydrothermal method.
[0075] Thus, this invention is applicable to the ink jet type recording head of various structures, unless it is contrary to the meaning.
[0076] Moreover, the ink jet type recording head of each [these] operation gestalt constitutes some recording head units possessing an ink cartridge etc. and ink passage open for free passage, and is carried in an ink jet type recording device. Drawing 11 is the schematic diagram showing an example of the ink jet type recording device.
[0077] As shown in drawing 11 , the carriage 3 which was formed removable and carried these recording head units 1A and 1B is formed free [shaft-orientations migration on the carriage shaft 5 with which cartridge 2A and 2B from which the recording head units 1A and 1B which have an ink jet type recording head constitute an ink supply means were attached in the body 4 of equipment]. These recording head units 1A and 1B shall carry out the regurgitation of a black ink constituent and the color ink constituent, respectively, for example.
[0078] And the carriage 3 carrying the recording head units 1A and 1B is moved in accordance with the carriage shaft 5 by being transmitted to carriage 3 through two or more gearings and timing belts 7 which the driving force of a drive motor 6 does not illustrate. On the other hand, along with carriage 3, the platen 8 is formed in the body 4 of equipment. Record sheet S which is record media, such as paper to which can rotate now with the driving force of the paper feed motor which is not illustrated, and paper was fed with the feed roller etc., winds this platen 8 around a platen 8, it is hung, and is conveyed.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the decomposition perspective view of the ink jet type recording head concerning the operation gestalt 1 of this invention.
[Drawing 2] It is drawing showing the ink jet type recording head concerning the operation gestalt 1 of this invention, and is the top view and sectional view of drawing 1 .
[Drawing 3] It is the perspective view showing the modification of the closure plate of drawing 1 .
[Drawing 4] It is the sectional view showing the thin-film-fabrication process of the operation gestalt 1 of this invention.
[Drawing 5] It is the sectional view showing the thin-film-fabrication process of the operation gestalt 1 of this invention.
[Drawing 6] It is the sectional view showing the thin-film-fabrication process of the operation gestalt 1 of this invention.
[Drawing 7] It is the top view and sectional view showing the important section of the ink jet type recording head concerning the operation gestalt 1 of this invention.
[Drawing 8] It is the top view showing the modification of the ink jet type recording head concerning the operation gestalt 1 of this invention.
[Drawing 9] It is the decomposition perspective view of the ink jet type recording head concerning other operation gestalten of this invention.
[Drawing 10] It is the sectional view showing the ink jet type recording head concerning other operation gestalten of this invention.
[Drawing 11] It is the schematic diagram of the ink jet type recording device concerning 1 operation gestalt of this invention.
[Description of Notations]
12 Pressure Generating Room
50 Elastic Membrane
60 Bottom Electrode Layer
61 Bottom Electrode Layer for Wiring
70 Piezo Electric Crystal Film
80 Top Electrode Layer
300 Piezoelectric Device
320 Piezo Electric Crystal Active Section
330 Piezo Electric Crystal Non-Activity Section

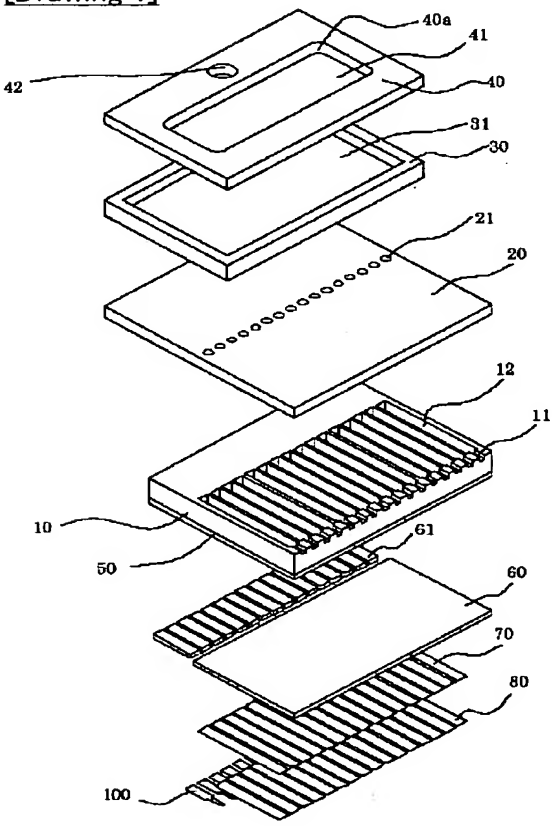
[Translation done.]

* NOTICES *

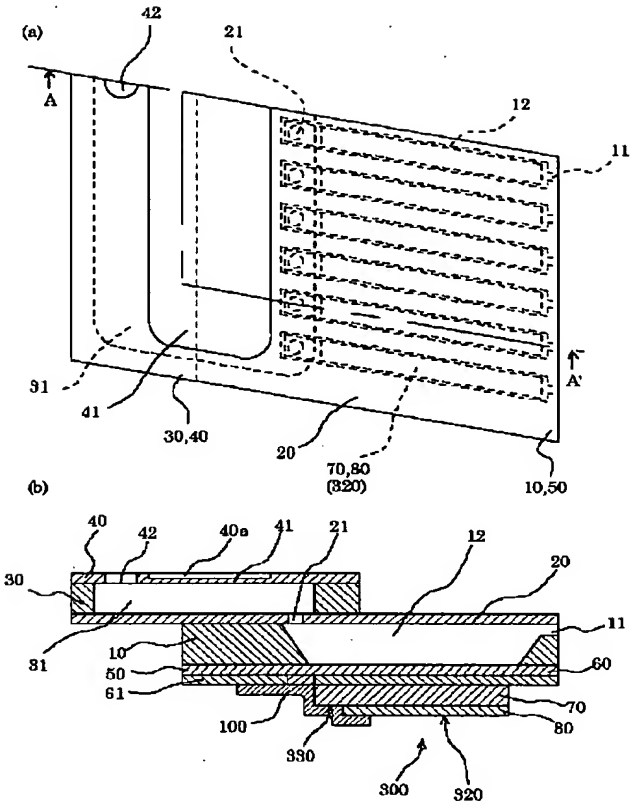
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

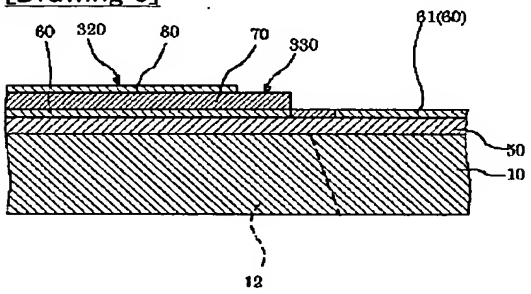
[Drawing 1]



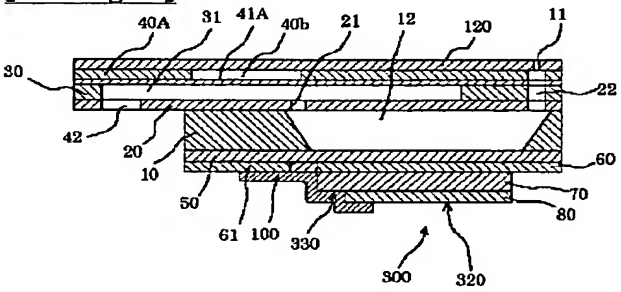
[Drawing 2]



[Drawing 6]

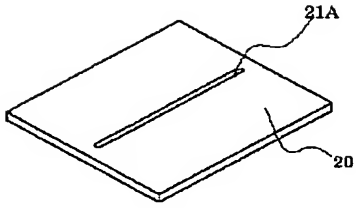


[Drawing 10]

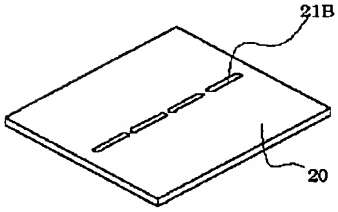


[Drawing 3]

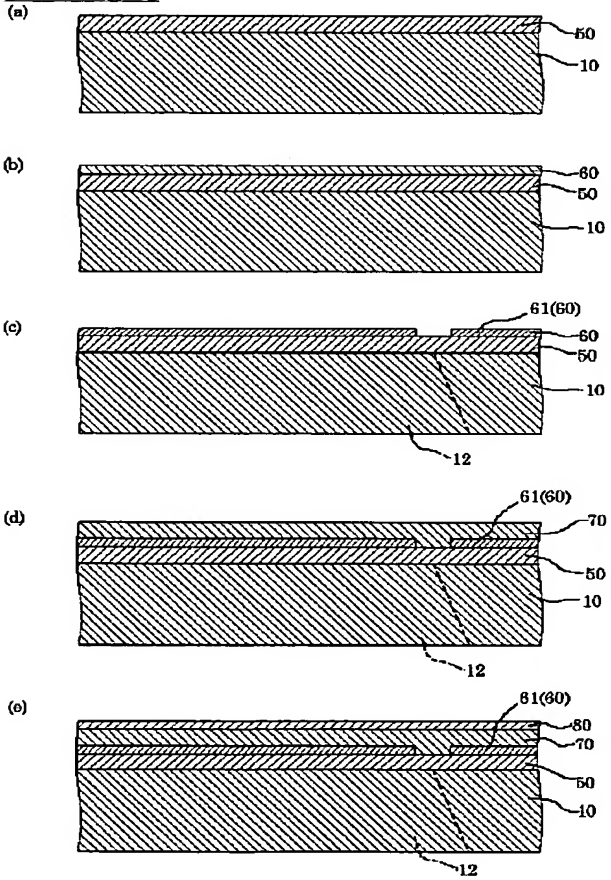
(a)



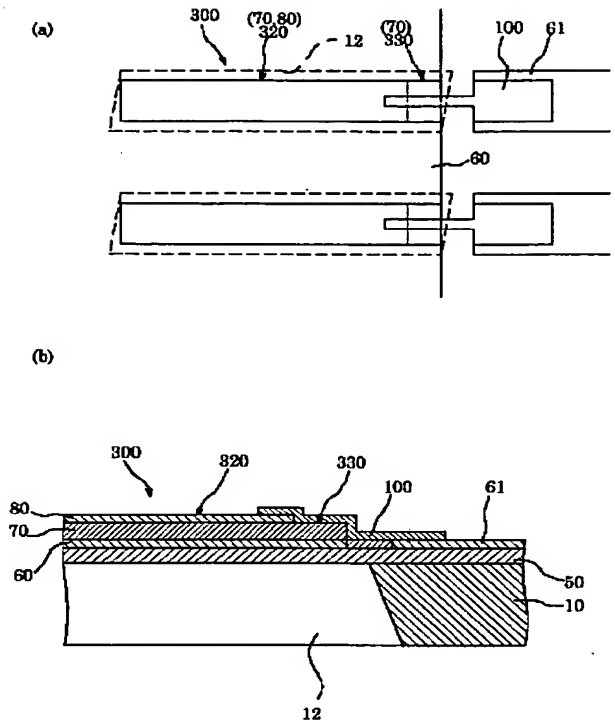
(b)



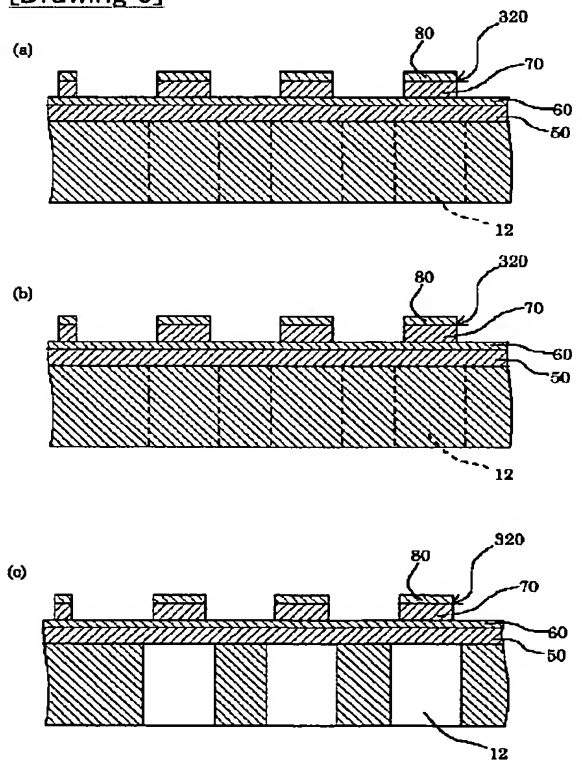
[Drawing 4]



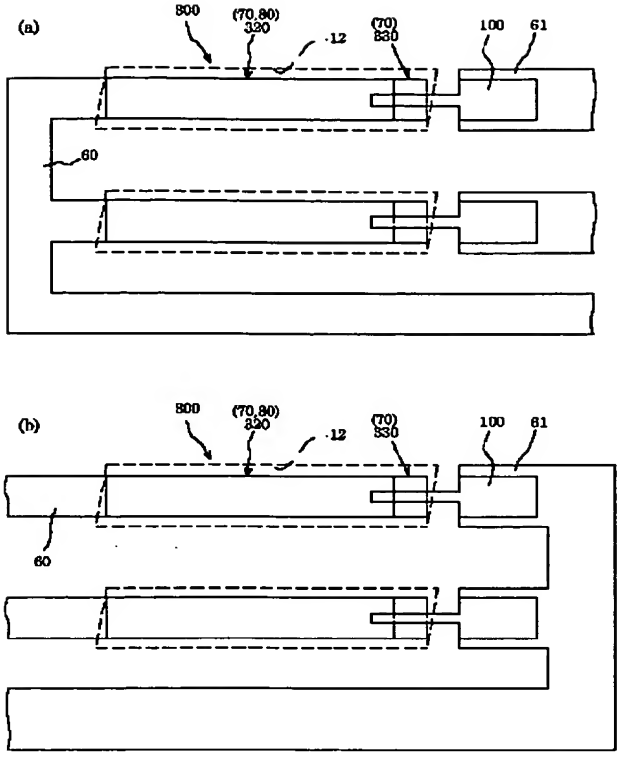
[Drawing 7]



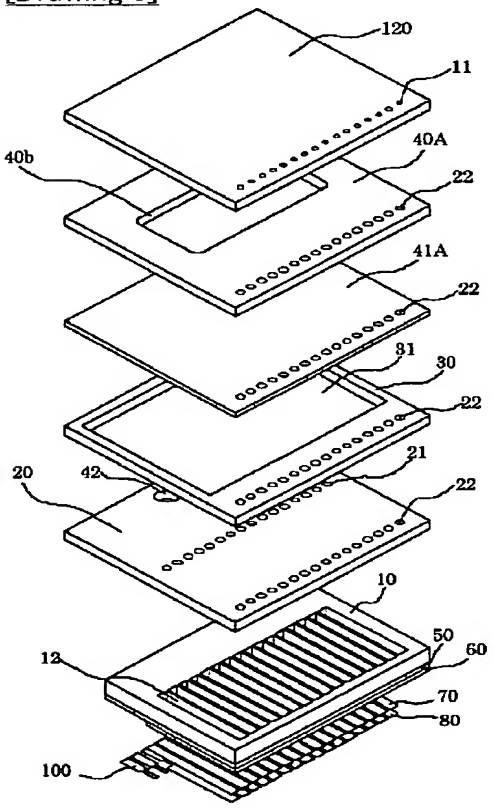
[Drawing 5]



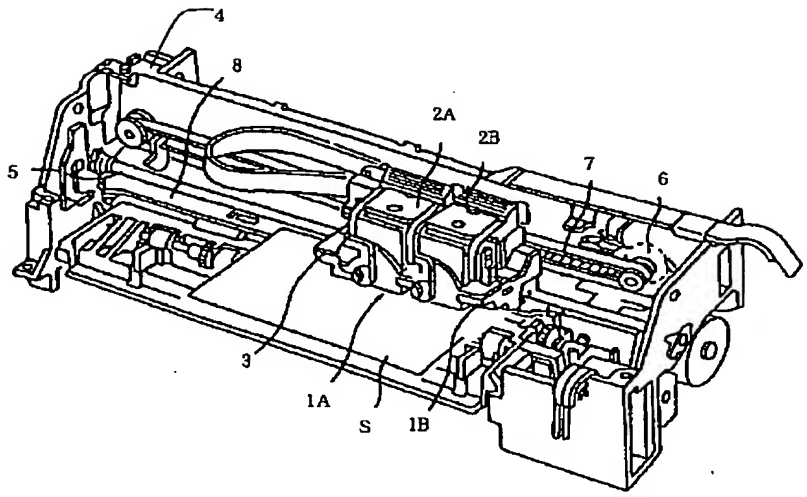
[Drawing 8]



[Drawing 9]



[Drawing 11]



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（A）　(11)特許出願公開番号
特開2000－263785
（P2000－263785A）
(43)公開日　平成12年９月26日(2000.9.26)

(51)Int.Cl.'	識別記号	ＦＩ		テーマコード'(参考)
Ｂ４１Ｊ　2/045		Ｂ４１Ｊ　3/04	１０３Ａ	２Ｃ０５７
2/055			１０３Ｈ	
2/16		Ｈ０１Ｌ　41/08	Ｃ	
Ｈ０１Ｌ　41/09		41/22	Ｚ	
41/22				

審査請求　未請求　請求項の数12　ＯＬ　（全 10 頁）

(21)出願番号　特願平11－73305

(22)出願日　平成11年３月18日(1999.3.18)

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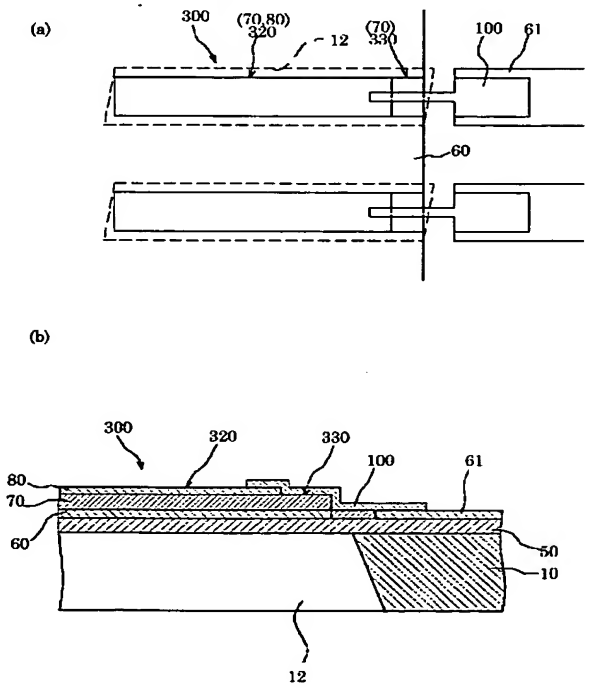
Ｆターム(参考)　20057 AF66 AF93 AG12 AG57 AG90
AG92 AG93 AP02 AP14 AP34
AP52 AQ02 BA03 BA14

(54)【発明の名称】　アクチュエータ装置及びその製造方法並びにインクジェット式記録ヘッド及びインクジェット式記録装置

(57)【要約】
【課題】　圧電体層の絶縁破壊を防止したアクチュエータ装置及びその製造方法、並びにインクジェット式記録ヘッド及びインクジェット式記録装置を提供する。
【解決手段】　上電極８０の端部は下電極６０の端部よりも内側に位置して前記圧電素子３００の実質的な駆動部となる圧電体能動部３２０の端部となっており、上電極８０の端部より外側に突出した下電極６０上に圧電体層７０を設けて実質的に駆動されない圧電体非能動部３３０を構成すると共に下電極６０の端部の外側にも圧電体層７０を設け、下電極６０端部近傍の圧電体層７０の絶縁破壊を防止する。



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【特許請求の範囲】

【請求項１】　基板の一方面に絶縁層を介して設けられた下電極、該下電極上に設けられた圧電体層及び該圧電体層上に設けられた上電極からなる圧電素子を具備するアクチュエータ装置において、

前記上電極の端部は前記下電極の端部よりも内側に位置して前記圧電素子の実質的な駆動部となる圧電体能動部の端部となっており、前記上電極の端部より外側に突出した前記下電極上には前記圧電体層が設けられて実質的に駆動されない圧電体非能動部を構成すると共に前記下電極の端部の外側にも前記圧電体層が設けられていることを特徴とするアクチュエータ装置。

【請求項２】　請求項１において、前記圧電素子が前記基板に形成された圧力発生室に対応する領域に設けられると共に前記圧電体能動部の端部が前記圧力発生室内の周壁より内側に位置することを特徴とするアクチュエータ装置。

【請求項３】　請求項１又は２において、前記圧電体層が前記下電極の端部と同一位置又はその外側まで延設されていることを特徴とするアクチュエータ装置。

【請求項４】　請求項１～３の何れかにおいて、前記下電極の端部の外側に設けられた圧電体層のさらに外側には、前記下電極とは不連続に設けられ且つ一端が外部配線に接続される配線用下電極が前記各圧電素子毎に設けられていることを特徴とするアクチュエータ装置。

【請求項５】　請求項１～４の何れかにおいて、前記下電極が複数の隣接する圧電素子に亘って連続的に設けられていることを特徴とするアクチュエータ装置。

【請求項６】　請求項１～４の何れかにおいて、前記下電極が各圧電素子毎にパターニングされていることを特徴とするアクチュエータ装置。

【請求項７】　請求項１～６の何れかのアクチュエータ装置の前記基板がノズル開口に連通する圧力発生室を画成する流路形成基板であり、該流路形成基板の他方面側に、前記ノズル開口を有するノズル形成基板が接合されていることを特徴とするインクジェット式記録ヘッド。

【請求項８】　請求項７において、前記圧力発生室がシリコン単結晶基板に異方性エッチングにより形成され、前記圧電素子の各層が薄膜及びリソグラフィ法により形成されたものであることを特徴とするインクジェット式記録ヘッド。

【請求項９】　請求項７又は８のインクジェット式記録ヘッドを具備することを特徴とするインクジェット式記録装置。

【請求項１０】　基板上に絶縁層を介して下電極層、圧電体層及び上電極層を順次積層して各層をパターニングし、前記下電極層、前記圧電体層及び前記上電極層からなる圧電素子を形成するアクチュエータ装置の製造方法において、

前記下電極層を形成すると共にパターニングして前記下電極層を除去した下電極層除去部を形成する第１の工程と、この上に前記圧電体層及び前記上電極層を成膜及びパターニングして前記圧電素子を形成すると共に前記上電極層の端部を前記下電極層の端部よりも内側に形成して前記圧電素子の実質的な駆動部となる圧電体能動部の端部とする第２の工程とを有することを特徴とするアクチュエータ装置の製造方法。

【請求項１１】　請求項１０において、前記第２の工程では、前記圧電素子を構成する各層を成膜後、当該圧電素子の前記下電極層の端部近傍に対応する領域の前記上電極層を除去することを特徴とするアクチュエータ装置の製造方法。

【請求項１２】　請求項１０において、前記第２の工程では、前記圧電素子を構成する前記下電極層及び前記圧電体層を成膜後、前記上電極層をマスク蒸着により前記圧電体層上の前記圧電素子の前記下電極端部近傍に対応する領域以外の領域に蒸着することを特徴とするアクチュエータ装置の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、圧電材料層に電圧を印加することにより変位させる圧電素子を有するアクチュエータ装置及びその製造方法に関し、特に、インク滴を吐出するノズル開口と連通する圧力発生室の一部を振動板で構成し、この振動板の表面に圧電素子を形成して圧電素子の変位によりインク滴を吐出させるインクジェット式記録ヘッド及びインクジェット式記録装置に関する。

【０００２】

【従来の技術】インク滴を吐出するノズル開口と連通する圧力発生室の一部を振動板で構成し、この振動板を圧電素子により変形させて圧力発生室のインクを加圧してノズル開口からインク滴を吐出させるインクジェット式記録ヘッドには、圧電素子の軸方向に伸長、収縮する縦振動モードの圧電アクチュエータを使用したものと、たわみ振動モードの圧電アクチュエータを使用したものの２種類が実用化されている。

【０００３】前者は圧電素子の端面を振動板に当接させることにより圧力発生室の容積を変化させることができて、高密度印刷に適したヘッドの製作が可能である反面、圧電素子をノズル開口の配列ピッチに一致させて櫛歯状に切り分けるという困難な工程や、切り分けられた圧電素子を圧力発生室に位置決めして固定する作業が必要となり、製造工程が複雑であるという問題がある。

【０００４】これに対して後者は、圧電材料のグリーンシートを圧力発生室の形状に合わせて貼付し、これを焼成するという比較的簡単な工程で振動板に圧電素子を作り付けることができるものの、たわみ振動を利用する関係上、ある程度の面積が必要となり、高密度配列が困難であるという問題がある。

【０００５】一方、後者の記録ヘッドの不都合を解消すべく、特開平５－２８６１３１号公報に見られるように、振動板の表面全体に亙って成膜技術により均一な圧電材料層を形成し、この圧電材料層をリソグラフィ法により圧力発生室に対応する形状に切り分けて各圧力発生室毎に独立するように圧電素子を形成したものが提案されている。

【０００６】これによれば圧電素子を振動板に貼付ける作業が不要となって、リソグラフィ法という精密で、かつ簡便な手法で圧電素子を作り付けることができるばかりでなく、圧電素子の厚みを薄くできて高速駆動が可能になるという利点がある。

【０００７】また、この場合、圧電材料層は振動板の表面全体に設けたままで少なくとも上電極のみを各圧力発生室毎に設けることにより、各圧力発生室に対応する圧電素子を駆動することができるが、単位駆動電圧当たりの変位量及び圧力発生室に対向する部分とその外部とを跨ぐ部分で圧電体層へかかる応力の問題から、圧電体能動部を構成する圧電体層及び上電極は、できるだけ圧力発生室外に出ないように形成することが望ましい。

【０００８】そこで、下電極をパターニングした後に、圧電体層及び上電極を成膜及びパターニングして圧電素子を形成すると共に、その一端部から圧電体層及び上電極を周壁上まで延設した構造が提案されている。

【０００９】

【発明が解決しようとする課題】しかしながら、上述の構造では、通常パターニングされた下電極上に、例えば、ゾルーゲル法等の湿式法、あるいはスパッタリング法等で圧電体層を成膜するため、下電極の端部近傍の圧電体層が他の部分よりも薄く形成されてしまう。この状態で電圧を印加すると、圧電体層の薄い部分で電界強度が大きくなってしまい、絶縁破壊が発生してしまうという問題がある。

【００１０】本発明は、このような事情に鑑み、圧電体層の絶縁破壊を防止したアクチュエータ装置及びその製造方法、並びにインクジェット式記録ヘッド及びインクジェット式記録装置を提供することを課題とする。

【００１１】

【課題を解決するための手段】上記課題を解決する本発明の第１の態様は、基板の一方面に絶縁層を介して設けられた下電極、該下電極上に設けられた圧電体層及び該圧電体層上に設けられた上電極からなる圧電素子を具備するアクチュエータ装置において、前記上電極の端部は前記下電極の端部よりも内側に位置して前記圧電素子の実質的な駆動部となる圧電体能動部の端部となっており、前記上電極の端部より外側に突出した前記下電極上には前記圧電体層が設けられて実質的に駆動されない圧電体非能動部を構成すると共に前記下電極の端部の外側にも前記圧電体層が設けられていることを特徴とするアクチュエータ装置にある。

【００１２】かかる第１の態様では、圧電体能動部の端部と下電極の端部との距離を離すことができ、圧電体能動部の長手方向端部での電界集中による絶縁破壊が防止される。

【００１３】本発明の第２の態様は、第１の態様において、前記圧電素子が前記基板に形成された圧力発生室に対応する領域に設けられると共に前記圧電体能動部の端部が前記圧力発生室内の周壁より内側に位置することを特徴とするアクチュエータ装置にある。

【００１４】かかる第２の態様では、圧電体能動部の駆動を妨げることがなく、圧電体層の絶縁破壊が防止される。

【００１５】本発明の第３の態様は、第１又は２の態様において、前記圧電体層が前記下電極の端部と同一位置又はその外側まで延設されていることを特徴とするアクチュエータ装置にある。

【００１６】かかる第３の態様では、上電極と下電極とが確実に絶縁され、下電極の端部近傍での圧電体層の絶縁破壊が確実に防止できる。

【００１７】本発明の第４の態様は、第１～３の何れかの態様において、前記下電極の端部の外側に設けられた圧電体層のさらに外側には、前記下電極とは不連続に設けられ且つ一端が外部配線に接続される配線用下電極が前記各圧電素子毎に設けられていることを特徴とするアクチュエータ装置にある。

【００１８】かかる第４の態様では、下電極と配線用下電極とが圧電体層によって確実に絶縁され、且つ容易に配線を形成することができる。

【００１９】本発明の第５の態様は、第１～４の何れかの態様において、前記下電極が複数の隣接する圧電素子に亙って連続的に設けられていることを特徴とするアクチュエータ装置にある。

【００２０】かかる第５の態様では、下電極の剛性が向上され、耐久性が向上する。

【００２１】本発明の第６の態様は、第１～４の何れかの態様において、前記下電極が各圧電素子毎にパターニングされていることを特徴とするアクチュエータ装置にある。

【００２２】かかる第６の態様では、圧電体能動部の駆動による変位量が向上する。

【００２３】本発明の第７の態様は、第１～６の何れかの態様のアクチュエータ装置の前記基板がノズル開口に連通する圧力発生室を画成する流路形成基板であり、該流路形成基板の他方面側に、前記ノズル開口を有するノズル形成基板が接合されていることを特徴とするインクジェット式記録ヘッドにある。

【００２４】かかる第７の態様では、圧電素子の駆動により、ノズル開口から良好なインク吐出を行うことのできるインクジェット式記録ヘッドを実現することができる。

【００２５】本発明の第８の態様は、第７の態様において、前記圧力発生室がシリコン単結晶基板に異方性エッチングにより形成され、前記圧電素子の各層が薄膜及びリソグラフィ法により形成されたものであることを特徴とするインクジェット式記録ヘッドにある。

【００２６】かかる第８の態様では、高密度のノズル開口を有するインクジェット式記録ヘッドを大量に且つ比較的容易に製造することができる。

【００２７】本発明の第９の態様は、第７又は８の態様のインクジェット式記録ヘッドを具備することを特徴とするインクジェット式記録装置にある。

【００２８】かかる第９の態様では、ヘッドの信頼性を向上したインクジェット式記録ヘッドを実現することができる。

【００２９】本発明の第１０の態様は、基板上に絶縁層を介して下電極層、圧電体層及び上電極層を順次積層して各層をパターニングし、前記下電極層、前記圧電体層及び前記上電極層からなる圧電素子を形成する圧電素子の形成方法において、前記下電極層を形成すると共にパターニングして前記下電極層を除去した下電極層除去部を形成する第１の工程と、この上に前記圧電体層及び前記上電極層を成膜及びパターニングして前記圧電素子を形成すると共に前記上電極層の端部を前記下電極層の端部よりも内側に形成して前記圧電素子の実質的な駆動部となる圧電体能動部の端部とする第２の工程とを有することを特徴とするアクチュエータ装置の製造方法にある。

【００３０】かかる第１０の態様では、圧電体能動部を比較的容易に形成することができる。

【００３１】本発明の第１１の態様は、第１０の態様において、前記第２の工程では、前記圧電素子を構成する各層を成膜後、当該圧電素子の前記下電極層の端部近傍に対応する領域の前記上電極層を除去することを特徴とするアクチュエータ装置の製造方法にある。

【００３２】かかる第１１の態様では、圧電体非能動部を比較的容易に形成することができる。

【００３３】本発明の第１２の態様は、第１０の態様において、前記第２の工程では、前記圧電素子を構成する前記下電極層及び前記圧電体層を成膜後、前記上電極層をマスク蒸着により前記圧電体層上の前記圧電素子の前記下電極端部近傍に対応する領域以外の領域に蒸着することを特徴とするアクチュエータ装置の製造方法にある。

【００３４】かかる第１２の態様では、圧電体非能動部を比較的容易に形成することができる。

【００３５】

【発明の実施の形態】以下に本発明を実施形態に基づいて詳細に説明する。

【００３６】（実施形態１）図１は、本発明の実施形態１に係るインクジェット式記録ヘッドを示す分解斜視図であり、図２は、その平面図及び１つの圧力発生室の長手方向における断面図である。

【００３７】図示するように、流路形成基板１０は、本実施形態では面方位（１１０）のシリコン単結晶基板からなる。流路形成基板１０としては、通常、１５０～３００μｍ程度の厚さのものが用いられ、望ましくは１８０～２８０μｍ程度、より望ましくは２２０μｍ程度の厚さのものが好適である。これは、隣接する圧力発生室間の隔壁の剛性を保ちつつ、配列密度を高くできるからである。

【００３８】流路形成基板１０の一方の面は開口面となり、他方の面には予め熱酸化により形成した二酸化シリコンからなる、厚さ１～２μｍの弾性膜５０が形成されている。

【００３９】一方、流路形成基板１０の開口面には、シリコン単結晶基板を異方性エッチングすることにより、ノズル開口１１、圧力発生室１２が形成されている。

【００４０】ここで、異方性エッチングは、シリコン単結晶基板を水酸化カリウム等のアルカリ溶液に浸漬すると、徐々に侵食されて（１１０）面に垂直な第１の（１１１）面と、この第１の（１１１）面と約７０度の角度をなし且つ上記（１１０）面と約３５度の角度をなす第２の（１１１）面とが出現し、（１１０）面のエッチングレートと比較して（１１１）面のエッチングレートが約１／１８０であるという性質を利用して行われるものである。かかる異方性エッチングにより、二つの第１の（１１１）面と斜めの二つの第２の（１１１）面とで形成される平行四辺形状の深さ加工を基本として精密加工を行うことができ、圧力発生室１２を高密度に配列することができる。

【００４１】本実施形態では、各圧力発生室１２の長辺を第１の（１１１）面で、短辺を第２の（１１１）面で形成している。この圧力発生室１２は、流路形成基板１０をほぼ貫通して弾性膜５０に達するまでエッチングすることにより形成されている。なお、弾性膜５０は、シリコン単結晶基板をエッチングするアルカリ溶液に侵される量がきわめて小さい。

【００４２】一方、各圧力発生室１２の一端に連通する各ノズル開口１１は、圧力発生室１２より幅狭で且つ浅く形成されている。すなわち、ノズル開口１１は、シリコン単結晶基板を厚さ方向に途中までエッチング（ハーフエッチング）することにより形成されている。なお、ハーフエッチングは、エッチング時間の調整により行われる。

【００４３】ここで、インク滴吐出圧力をインクに与える圧力発生室１２の大きさと、インク滴を吐出するノズル開口１１の大きさとは、吐出するインク滴の量、吐出スピード、吐出周波数に応じて最適化される。例えば、１インチ当たり３６０個のインク滴を記録する場合、ノズル開口１１は数十μｍの溝幅で精度よく形成する必要

がある。

【００４４】また、各圧力発生室１２と後述する共通インク室３１とは、後述する封止板２０の各圧力発生室１２の一端部に対応する位置にそれぞれ形成されたインク供給連通口２１を介して連通されており、インクはこのインク供給連通口２１を介して共通インク室３１から供給され、各圧力発生室１２に分配される。

【００４５】封止板２０は、前述の各圧力発生室１２に対応したインク供給連通口２１が穿設された、厚さが例えば、０．１～１ｍｍで、線膨張係数が３００℃以下で、例えば２．５～４．５［×10^{-6}／℃］であるガラスセラミックスからなる。なお、インク供給連通口２１は、図３（ａ），（ｂ）に示すように、各圧力発生室１２のインク供給側端部の近傍を横断する一つのスリット孔２１Ａでも、あるいは複数のスリット孔２１Ｂであってもよい。封止板２０は、一方の面で流路形成基板１０の一面を全面的に覆い、シリコン単結晶基板を衝撃や外力から保護する補強板の役目も果たす。また、封止板２０は、他面で共通インク室３１の一壁面を構成する。

【００４６】共通インク室形成基板３０は、共通インク室３１の周壁を形成するものであり、ノズル開口数、インク滴吐出周波数に応じた適正な厚みのステンレス板を打ち抜いて作製されたものである。本実施形態では、共通インク室形成基板３０の厚さは、０．２ｍｍとしている。

【００４７】インク室側板４０は、ステンレス基板からなり、一方の面で共通インク室３１の一壁面を構成するものである。また、インク室側板４０には、他方の面の一部にハーフエッチングにより凹部４０ａを形成することにより薄肉壁４１が形成され、さらに、外部からのインク供給を受けるインク導入口４２が打抜き形成されている。なお、薄肉壁４１は、インク滴吐出の際に発生するノズル開口１１と反対側へ向かう圧力を吸収するためのもので、他の圧力発生室１２に、共通インク室３１を経由して不要な正又は負の圧力が加わるのを防止する。本実施形態では、インク導入口４２と外部のインク供給手段との接続時等に必要な剛性を考慮して、インク室側板４０を０．２ｍｍとし、その一部を厚さ０．０２ｍｍの薄肉壁４１としているが、ハーフエッチングによる薄肉壁４１の形成を省略するために、インク室側板４０の厚さを初めから０．０２ｍｍとしてもよい。

【００４８】一方、流路形成基板１０の開口面とは反対側の弾性膜５０の上には、厚さが例えば、約０．５μｍの下電極膜６０と、厚さが例えば、約１μｍの圧電体膜７０と、厚さが例えば、約０．１μｍの上電極膜８０とが、後述するプロセスで積層形成されて、圧電素子３００を構成している。ここで、圧電素子３００は、下電極膜６０、圧電体膜７０、及び上電極膜８０を含む部分をいう。一般的には、圧電素子３００の何れか一方の電極を共通電極とし、他方の電極及び圧電体膜７０を各圧力発生室１２毎にパターニングして構成する。そして、ここではパターニングされた何れか一方の電極及び圧電体膜７０から構成され、両電極への電圧の印加により圧電歪みが生じる部分を圧電体能動部３２０という。本実施形態では、下電極膜６０は圧電素子３００の共通電極とし、上電極膜８０を圧電素子３００の個別電極としているが、駆動回路や配線の都合でこれを逆にしても支障はない。何れの場合においても、各圧力発生室毎に圧電体能動部が形成されていることになる。また、ここでは、圧電素子３００と当該圧電素子３００の駆動により変位が生じる振動板とを合わせて圧電アクチュエータと称する。

【００４９】ここで、シリコン単結晶基板からなる流路形成基板１０上に、圧電体膜７０等を形成するプロセスを図４～図６を参照しながら説明する。なお、図４及び図６は、圧力発生室１２の長手方向の断面図であり、図５は圧力発生室１２の幅方向の断面図である。

【００５０】まず、図４（ａ）に示すように、流路形成基板１０となるシリコン単結晶基板のウェハを約１１００℃の拡散炉で熱酸化して二酸化シリコンからなる弾性膜５０を形成する。

【００５１】次に、図４（ｂ）に示すように、スパッタリングで下電極膜６０を形成する。下電極膜６０の材料としては、白金、イリジウム、酸化イリジウム又はこれらの合金等が好適である。これは、ゾルーゲル法やスパッタリング法で成膜する後述の圧電体膜７０は、成膜後に大気雰囲気下又は酸素雰囲気下で６００～１０００℃程度の温度で焼成して結晶化させる必要があるからである。すなわち、下電極膜６０の材料は、このような高温、酸化雰囲気下で導電性を保持できなければならず、殊に、圧電体膜７０としてチタン酸ジルコン酸鉛（ＰＺＴ）を用いた場合には、酸化鉛の拡散による導電性の変化が少ないことが望ましく、これらの理由から白金、イリジウム、酸化イリジウム又はこれらの合金等が好適である。

【００５２】次に、図４（ｃ）に示すように、下電極膜６０を各圧力発生室１２毎に所定の形状にパターニングする。すなわち、圧力発生室１２の長手方向一端部の周壁に対向する領域の下電極膜６０をパターニングして、各圧力発生室１２に対応してそれぞれ独立した配線用下電極膜６１を形成する。

【００５３】次に、図４（ｄ）に示すように、圧電体膜７０を成膜する。本実施形態では、金属有機物を溶媒に溶解・分散したいわゆるゾルを塗布乾燥してゲル化し、さらに高温で焼成することで金属酸化物からなる圧電体膜７０を得る、いわゆるゾルーゲル法を用いて形成した。圧電体膜７０の材料としては、チタン酸ジルコン酸鉛系の材料がインクジェット式記録ヘッドに使用する場合には好適である。なお、この圧電体膜７０の成膜方法は、特に限定されず、例えば、スパッタリング法で形成

してもよい。

【００５４】さらに、ゾルーゲル法又はスパッタリング法等によりチタン酸ジルコン酸鉛の前駆体膜を形成後、アルカリ水溶液中での高圧処理法にて低温で結晶成長させる方法を用いてもよい。

【００５５】次に、図４（ｅ）に示すように、上電極膜８０を成膜する。上電極膜８０は、導電性の高い材料であればよく、アルミニウム、金、ニッケル、白金等の多くの金属や、導電性酸化物等を使用できる。本実施形態では、白金をスパッタリングにより成膜している。

【００５６】その後、図５（ａ）に示すように、圧電体膜７０及び上電極膜８０のみをエッチングして圧電体能動部３２０のパターニングを行う。次いで、図６に示すように、各圧電体能動部３２０の配線用下電極膜６１側の端部近傍の上電極膜８０をエッチングすることにより、圧電体能動部３２０の端部には、圧電体膜７０を有するが実質的に駆動されない圧電体非駆動部３３０が形成される。以上が膜形成プロセスである。また、このようにして膜形成を行った後、図５（ｂ）に示すように、前述したアルカリ溶液によるシリコン単結晶基板の異方性エッチングを行い、圧力発生室１２等を形成する。

【００５７】このように形成されたインクジェット式記録ヘッドの要部平面及び断面を図７に示す。

【００５８】図７に示すように、圧電体能動部３２０を構成する圧電体膜７０及び上電極膜８０は基本的には各圧力発生室１２内にパターニングされている。一方、下電極膜６０は、並設された複数の圧力発生室１２に対応する領域に亘って設けられ、且つ圧力発生室１２の長手方向一端部側では圧力発生室１２に対応する領域の内側でパターニングされている。

【００５９】また、本実施形態では、上電極膜８０の一端部が下電極膜６０の端部よりも内側に位置しており、この上電極膜８０の端部が圧電体能動部３２０の端部となっている。また、圧電体膜７０の端部は下電極膜６０の端部と略同一位置であり上電極膜８０の端部よりも外側に突出した下電極膜６０上にも圧電体膜７０は形成されているが、この部分は実質的に駆動されない圧電体非能動部３３０となっている。

【００６０】また、この圧電体非能動部３３０側の圧力発生室１２の周壁上の下電極膜６０は、各圧電体能動部３２０毎に独立してパターニングされ、各圧電体能動部３２０の配線として用いられる配線用下電極膜６１となっている。そして、この配線用下電極膜６１は、一端が図示しない外部端子に接続されると共に、圧電体非能動部３３０上に延設されたリード電極１００を介して圧電体能動部３２０の上電極膜８０と接続されている。なお、この配線用下電極膜６１と下電極膜６０との間の下電極膜６０がパターニングされた部分には、本実施形態では、圧電体膜７０が除去されずに残留されており下電極膜６０とリード電極１００とが絶縁されている。

【００６１】このように本実施形態では、圧電体能動部３２０のリード電極１００の引き出し側の端部外側に、例えば、上電極膜８０を除去することにより、連続的に圧電体非能動部３３０を設けるようにした。これにより、圧電体能動部３２０の端部である上電極膜８０の端部と下電極膜６０の端部との距離を大きくすることができる。このため、圧電体能動部３２０への電圧印加によっても、圧電体能動部３２０の端部での電界強度が大きくなることがなく、圧電体膜７０の絶縁破壊等を防止することができる。また、圧電体能動部３２０の圧電体膜７０の厚さが均一となるため圧電特性が向上する。

【００６２】なお、本実施形態では、圧電体能動部３２０の各層を形成後、長手方向一端部の上電極膜８０を除去することにより圧電体非能動部３３０としたが、この方法に限定されず、例えば、下電極膜６０の端部近傍に対応する領域の圧電体膜７０をマスクで覆った状態で上電極膜８０を蒸着するいわゆるマスク蒸着により、下電極膜６０の端部近傍の圧電体膜７０上に上電極膜８０を蒸着しないようにし、この部分を圧電体非能動部３３０としてもよい。

【００６３】また、本実施形態では、圧電体膜７０の端部を下電極膜６０の端部と同一位置としたが、これに限定されず、さらに外側、例えば、配線用下電極膜６１に対向する領域まで延設するようにしてもよい。

【００６４】さらに、本実施形態では、下電極膜６０を複数の隣接する圧電素子３００に亘って連続的に設けるようにしたが、これに限定されず、例えば、各圧電素子３００毎にパターニングして、圧力発生室１２のリード電極１００の引き出し側とは反対側から外部へ引き出すようにしてもよい。この場合、図８（ａ）に示すように、各圧力発生室１２から引き出された下電極膜６０を周壁上で連結して共通電極としてもよいし、または、図８（ｂ）に示すように、各圧電素子３００毎に設けられた配線用下電極膜６１を連結して共通電極として、下電極膜６０を各圧電素子３００の個別電極としてもよい。

【００６５】また、このように下電極膜６０を各圧電素子３００毎にパターニングした場合には、圧電体膜７０を下電極膜６０よりも広い幅で形成し、下電極膜６０の幅方向両端の側面を圧電体膜７０で覆うようにしてもよい。

【００６６】以上説明した圧電体能動部３２０及び圧力発生室１２等の一連の膜形成及び異方性エッチングにより、一枚のウェハ上に多数のチップを同時に形成し、プロセス終了後、図１に示すような一つのチップサイズの流路形成基板１０毎に分割する。また、分割した流路形成基板１０を、封止板２０、共通インク室形成基板３０、及びインク室側板４０と順次接着して一体化し、インクジェット式記録ヘッドとする。

【００６７】また、このように構成したインクジェットヘッドは、図示しない外部インク供給手段と接続したイ

ンク導入口４２からインクを取り込み、共通インク室３１からノズル開口１１に至るまで内部をインクで満たした後、図示しない外部の駆動回路からの記録信号に従い、上電極膜８０と下電極膜６０との間に電圧を印加し、弾性膜５０、下電極膜６０及び圧電体膜７０をたわみ変形させることにより、圧力発生室１２内の圧力が高まりノズル開口１１からインク滴が吐出する。

【００６８】（他の実施形態）以上、本発明の各実施形態を説明したが、インクジェット式記録ヘッドの基本的構成は上述したものに限定されるものではない。

【００６９】例えば、上述した封止板２０の他、共通インク室形成板３０をガラスセラミックス製としてもよく、さらには、薄肉膜４１を別部材としてガラスセラミックス製としてもよく、材料、構造等の変更は自由である。

【００７０】また、上述した実施形態では、ノズル開口を流路形成基板１０の端面に形成しているが、面に垂直な方向に突出するノズル開口を形成してもよい。

【００７１】このように構成した実施形態の分解斜視図を図９、その流路の断面を図１０にぞれぞれ示す。この実施形態では、ノズル開口１１が圧電素子とは反対のノズル形成基板１２０に穿設され、これらノズル開口１１と圧力発生室１２とを連通するノズル連通口２２が、封止板２０，共通インク室形成板３０及び薄肉板４１Ａ及びインク室側板４０Ａを貫通するように配されている。

【００７２】なお、本実施形態は、その他、薄肉板４１Ａとインク室側板４０Ａとを別部材とし、インク室側板４０Ａに開口４０ｂを形成した以外は、基本的に上述した実施形態と同様であり、同一部材には同一符号を付して重複する説明は省略する。

【００７３】勿論、以上説明した各実施形態は、適宜組み合わせて実施することにより、より一層の効果を奏するものであることは言うまでもない。

【００７４】また、以上説明した各実施形態は、成膜及びリソグラフィプロセスを応用することにより製造できる薄膜型のインクジェット式記録ヘッドを例にしたが、勿論これに限定されるものではなく、例えば、基板を積層して圧力発生室を形成するもの、あるいはグリーンシートを貼付もしくはスクリーン印刷等により圧電体膜を形成するもの、又は水熱法等の結晶成長により圧電体膜を形成するもの等、各種の構造のインクジェット式記録ヘッドに本発明を採用することができる。

【００７５】このように、本発明は、その趣旨に反しない限り、種々の構造のインクジェット式記録ヘッドに応用することができる。

【００７６】また、これら各実施形態のインクジェット式記録ヘッドは、インクカートリッジ等と連通するインク流路を具備する記録ヘッドユニットの一部を構成して、インクジェット式記録装置に搭載される。図１１は、そのインクジェット式記録装置の一例を示す概略図である。

【００７７】図１１に示すように、インクジェット式記録ヘッドを有する記録ヘッドユニット１Ａ及び１Ｂは、インク供給手段を構成するカートリッジ２Ａ及び２Ｂが着脱可能に設けられ、この記録ヘッドユニット１Ａ及び１Ｂを搭載したキャリッジ３は、装置本体４に取り付けられたキャリッジ軸５に軸方向移動自在に設けられている。この記録ヘッドユニット１Ａ及び１Ｂは、例えば、それぞれブラックインク組成物及びカラーインク組成物を吐出するものとしている。

【００７８】そして、駆動モータ６の駆動力が図示しない複数の歯車およびタイミングベルト７を介してキャリッジ３に伝達されることで、記録ヘッドユニット１Ａ及び１Ｂを搭載したキャリッジ３はキャリッジ軸５に沿って移動される。一方、装置本体４にはキャリッジ３に沿ってプラテン８が設けられている。このプラテン８は図示しない紙送りモータの駆動力により回転できるようになっており、給紙ローラなどにより給紙された紙等の記録媒体である記録シートＳがプラテン８に巻き掛けられて搬送されるようになっている。

【００７９】

【発明の効果】以上説明したように本発明では、上電極膜の端部を下電極膜の端部よりも内側として圧電体能動部の長手方向一端部側に上電極膜を有さない圧電体非能動部を設け、圧電体能動部の端部と下電極膜の端部との距離を離すようにした。これにより、圧電体能動部の端部近傍での絶縁破壊を防止することができ、耐久性及び信頼性を向上することができる。

【図面の簡単な説明】

【図１】本発明の実施形態１に係るインクジェット式記録ヘッドの分解斜視図である。

【図２】本発明の実施形態１に係るインクジェット式記録ヘッドを示す図であり、図１の平面図及び断面図である。

【図３】図１の封止板の変形例を示す斜視図である。

【図４】本発明の実施形態１の薄膜製造工程を示す断面図である。

【図５】本発明の実施形態１の薄膜製造工程を示す断面図である。

【図６】本発明の実施形態１の薄膜製造工程を示す断面図である。

【図７】本発明の実施形態１に係るインクジェット式記録ヘッドの要部を示す平面図及び断面図である。

【図８】本発明の実施形態１に係るインクジェット式記録ヘッドの変形例を示す平面図である。

【図９】本発明の他の実施形態に係るインクジェット式記録ヘッドの分解斜視図である。

【図１０】本発明の他の実施形態に係るインクジェット式記録ヘッドを示す断面図である。

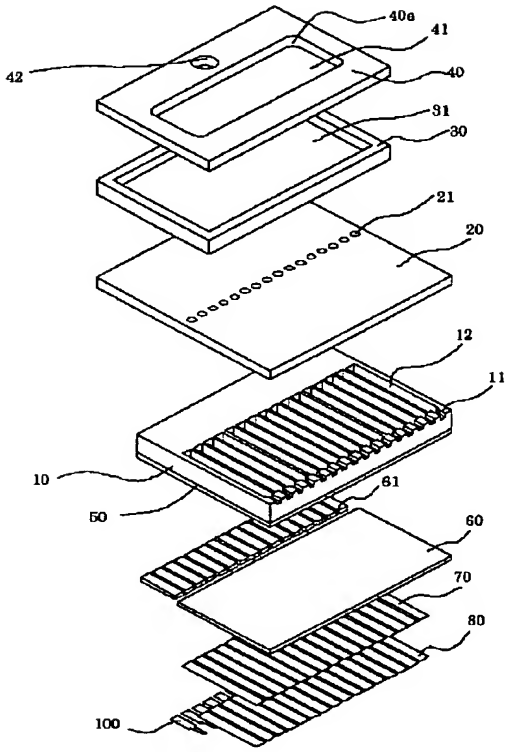
【図１１】本発明の一実施形態に係るインクジェット式

記録装置の概略図である。

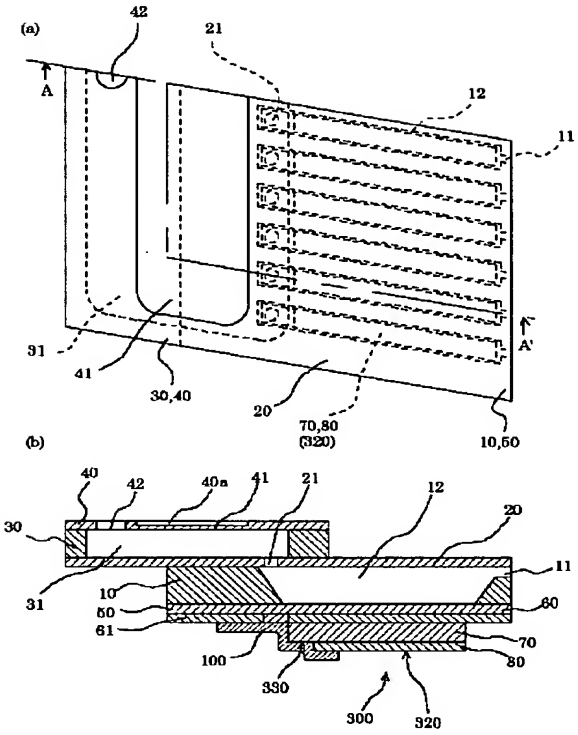
【符号の説明】

１２　圧力発生室
５０　弾性膜
６０　下電極膜
６１　配線用下電極膜
７０　圧電体膜
８０　上電極膜
３００　圧電素子
３２０　圧電体能動部
３３０　圧電体非能動部

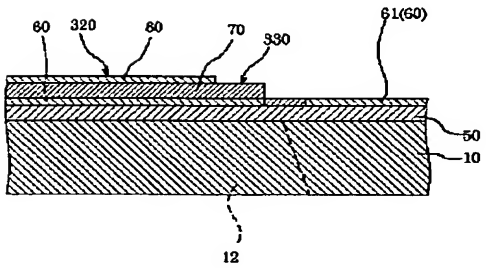
【図１】



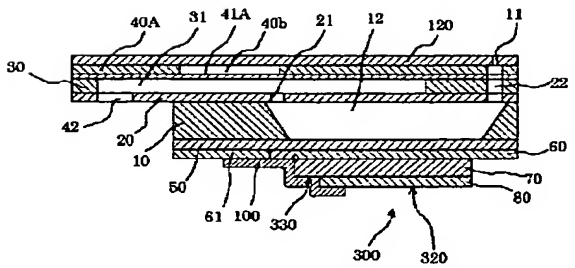
【図２】



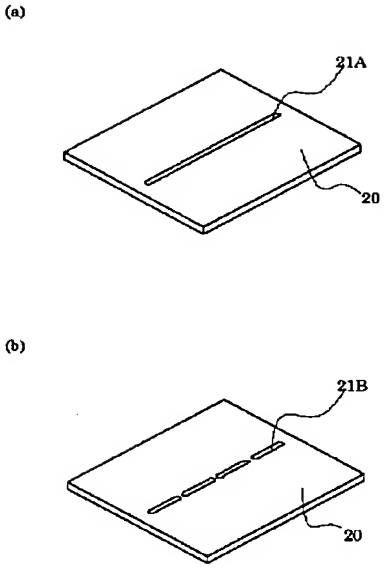
【図６】



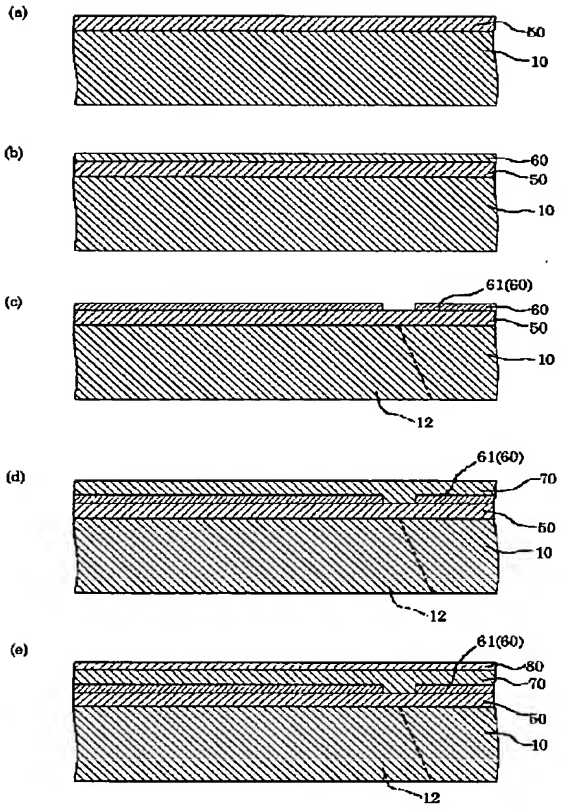
【図１０】



【図３】


(a)
21A
20
(b)
21B
20

【図４】


(a)
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10
(b)
60
50
10
(c)
61(60)
60
50
10
12
(d)
61(60)
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(e)
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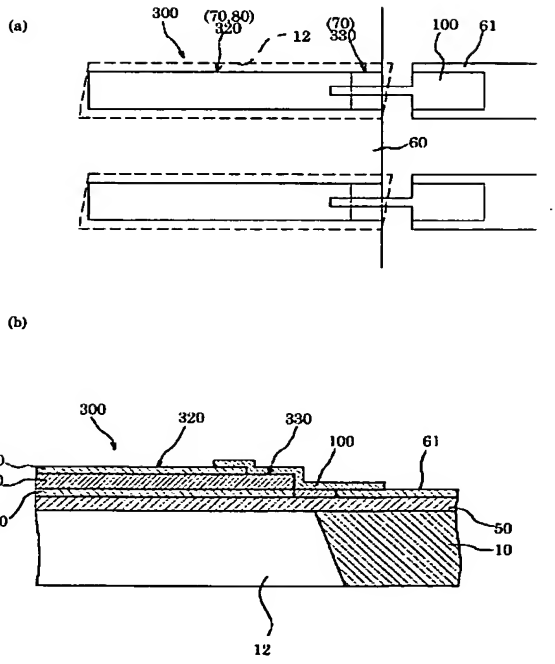
50
10
12

【図７】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(70)
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(b)
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320
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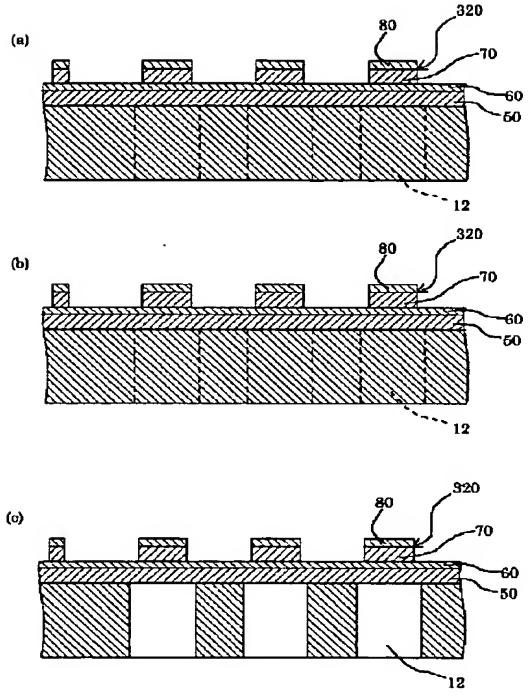
80
70
60
50
10
12

【図５】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(c)
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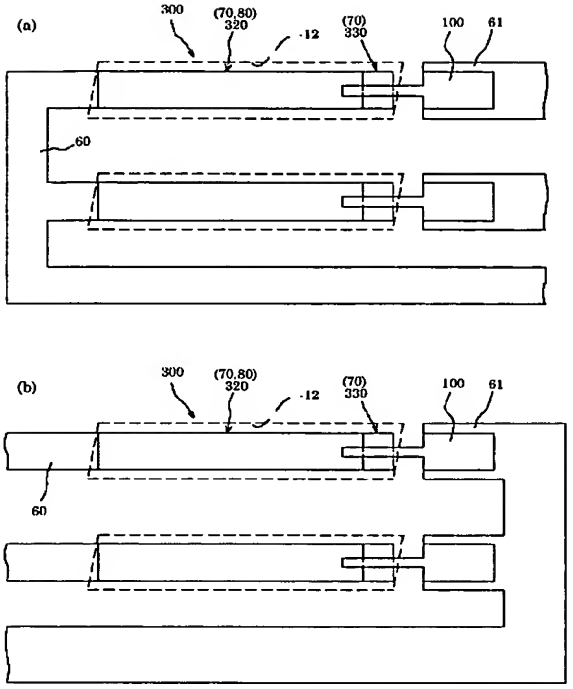
70
60
50
12

【図８】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(70,80)
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(70)
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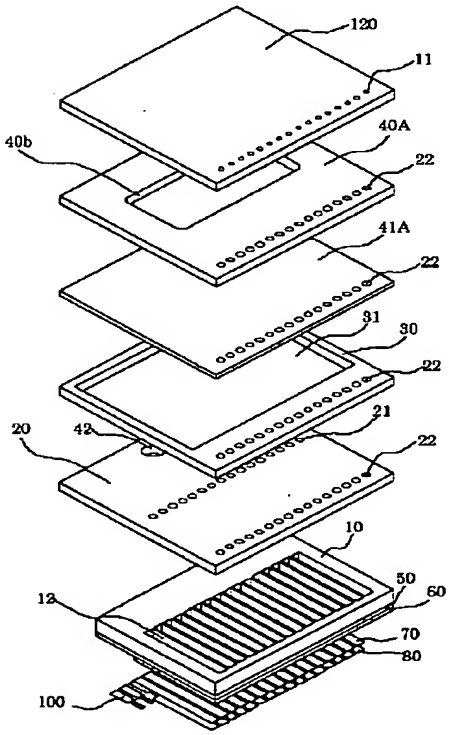
(b)
300
(70,80)
320
12
(70)
330
100
61
60

【図９】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41A
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12
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60
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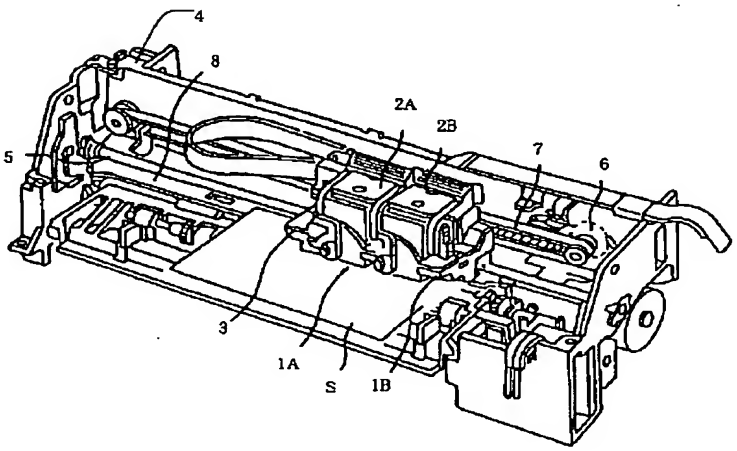
100

【図１１】


4
8
2A
2B
7
6
5
3
1A
S
1B